WAC 51-11C-40300 Section C403--Mechanical systems.

NEW SECTION

WAC 51-11C-40310 Section C403.1--General.

- **C403.1 General.** Mechanical systems and equipment serving heating, cooling, ventilating, and other needs shall comply with Section C403.2 (referred to as the mandatory provisions) and either:
 - 1. Section C403.3 (Simple systems); or
 - 2. Section C403.4 (Complex systems).

EXCEPTION:

Energy using equipment used by a manufacturing, industrial or commercial process other than for conditioning spaces or maintaining comfort and amenities for the occupants and not otherwise regulated by C403.2.3, Tables C403.2.1 (1) through (9) inclusive, C403.2.4.5, C403.2.5.4, C403.2.8, C403.2.13, C403.4.6, C403.5, C403.6, C404.2, or Table C404.2. Data center HVAC equipment is not covered by this exception.

Walk-in coolers and walk-in freezers shall comply with Section C403.5. Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.6.

NEW SECTION

WAC 51-11C-40320 Section C403.2--Provisions applicable to all mechanical systems.

C403.2 Provisions applicable to all mechanical systems (Mandatory). Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Sections C403.2.1 through C403.2.11.

NEW SECTION

WAC 51-11C-40321 Section C403.2.1--Calculation of heating and cooling loads.

C403.2.1 Calculation of heating and cooling loads. Design loads

shall be determined in accordance with the procedures described in ANSI/ASHRAE/ACCA Standard 183. The design loads shall account for the building envelope, lighting, ventilation and occupancy loads based on the project design. Heating and cooling loads shall be adjusted to account for load reductions that are achieved where energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE HVAC Systems and Equipment Handbook. Alternatively, design loads shall be determined by an approved equivalent computation procedure, using the design parameters specified in Chapter 3.

NEW SECTION

WAC 51-11C-40322 Section C403.2.2--Equipment and systems sizing.

C403.2.2 Equipment and system sizing. The output capacity of heating and cooling equipment and systems shall not exceed the loads calculated in accordance with Section C403.2.1. A single piece of equipment providing both heating and cooling shall satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.

EXCEPTIONS:

- 1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.
- 2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that have the capability to sequence the operation of each unit based on load.

NEW SECTION

WAC 51-11C-40323 Section C403.2.3--HVAC equipment performance requirements.

C403.2.3 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables C403.2.3(1), C403.2.3(2), C403.2.3(3), C403.2.3(4), C403.2.3(5), C403.2.3(6), C403.2.3(7) and C403.2.3(8) when tested and rated in accordance with the applicable test procedure. Plate-type liquid-to-liquid heat exchangers shall meet the minimum requirements of Table C403.2.3(9). efficiency The shall be verified certification and listed under an approved certification program or, if no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different

manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

Gas-fired and oil-fired forced air furnaces with input ratings $\geq 225,000$ Btu/h (65 kW) and all unit heaters shall also have an intermittent ignition or interrupted device (IID), and have either mechanical draft (including power venting) or a flue damper. A vent damper is an acceptable alternative to a flue damper for furnaces where combustion air is drawn from the conditioned space. All furnaces with input ratings $\geq 225,000$ Btu/h (65 kW), including electric furnaces, that are not located within the conditioned space shall have jacket losses not exceeding 0.75 percent of the input rating.

Chilled water plants and buildings with more than 500 tons total capacity shall not have more than 100 tons provided by aircooled chillers.

EXCEPTIONS:

- 1. Where the designer demonstrates that the water quality at the building site fails to meet manufacturer's specifications for the use of water-cooled equipment.
- Air-cooled chillers with minimum efficiencies at least 10 percent higher than those listed in Table C403.2.3(7).
 Replacement of existing equipment.

C403.2.3.1 Water-cooled centrifugal chilling packages. Equipment not designed for operation at AHRI Standard 550/590 test conditions of 44°F (7°C) leaving chilled-water temperature and 85°F (29°C) entering condenser water temperature with 3 gpm/ton (0.054 I/s \bullet kW) condenser water flow shall have maximum full-load kW/ton and NPLV ratings adjusted using Equations C4-3 and C4-4.

Adjusted minimum full-load COP ratings = (Full-load COP from Table 6.8.1C of AHRI Standard 550/590) $\times K_{adj}$

(Equation C4-3)

Adjusted minimum NPLV rating = (IPLV from Table 6.8.1C of AHRI Standard 550/590) $\times K_{adj}$

(Equation C4-4)

Where:

 $K_{adj} = A \times B$

 $A = 0.0000015318 \times (LIFT)^4$

 $0.000202076 \times (LIFT)^3 + 0.0101800 \times (LIFT)^2$ -

 $0.264958 \times LIFT + 3.930196$

B = $0.0027 \times L_{v_0}^{Evap}$ (°C) + 0.982

LIFT = $L_{ve}^{Cond} - L_{ve}^{Evap}$

 L_{vg}^{Cond} = Full-load condenser leaving water temperature (°C)

 L_{vp}^{Evap} = Full-load leaving evaporator temperature (°C)

SI units shall be used in the K_{adj} equation.

The adjusted full-load and NPLV values shall only be applicable for centrifugal chillers meeting all of the following full-load design ranges:

- 1. The leaving evaporator fluid temperature is not less than $36^{\circ}F$ (2.2°C).
- 2. The leaving condenser fluid temperature is not greater than $115\,^{\circ}\text{F}$ (46.1°C).

3. LIFT is not less than 20°F (11.1°C) and not greater than $80^{\circ}F$ (44.4°C).

EXCEPTION:

Centrifugal chillers designed to operate outside of these ranges need not comply with this code.

C403.2.3.2 Positive displacement (air- and water-cooled) chilling packages. Equipment with a leaving fluid temperature higher than 32°F (0°C), shall meet the requirements of Table C403.2.3(7) when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure.

C403.2.3.3 Packaged electric heating and cooling equipment. Packaged electric equipment providing both heating and cooling with a total cooling capacity greater than 20,000 Btu/h shall be a heat pump.

EXCEPTION:

Unstaffed equipment shelters or cabinets used solely for personal wireless service facilities.

C403.2.3.4 Humidification. If an air economizer is required on a cooling system for which humidification equipment is to be provided to maintain minimum indoor humidity levels, then the humidifier shall be of the adiabatic type (direct evaporative media or fog atomization type).

EXCEPTIONS:

- 1. Health care facilities where WAC 246-320-525 allows only steam injection humidifiers in duct work downstream of final filters
- 2. Systems with water economizer.
- $3.\ 100\%$ outside air systems with no provisions for air recirculation to the central supply fan.
- 4. Nonadiabatic humidifiers cumulatively serving no more than 10% of a building's air economizer capacity as measured in cfm. This refers to the system cfm serving rooms with stand alone or duct mounted humidifiers.

NEW SECTION

WAC 51-11C-403231 Table C403.2.3(1)--Minimum efficiency requirements--Electrically operated unitary air conditioners and condensing units.

Table C403.2.3(1)A
Minimum Efficiency Requirements--Electrically Operated Unitary
Air Conditioners and Condensing Units

				Minimum 1	Efficiency	
Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Before 6/1/2011	As of 6/1/2011	Test Procedure ^a
Air conditioners, air cooled	< 65,000 Btu/h ^b	All	Split System	13.0 SEER	13.0 SEER	
			Single Package	13.0 SEER	13.0 SEER	
Through-the-wall (air cooled)	$\leq 30,000 \text{ Btu/h}^b$	All	Split System	12.0 SEER	12.0 SEER	AHRI 210/240
			Single Package	12.0 SEER	12.0 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.2 EER 11.4 IEER	11.2 EER 11.4 IEER	
		All other	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	
Air conditioners, air cooled	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	AHRI 340/360

				Minimum	Efficiency	
	g		Subcategory or	Before	As of	
Equipment Type	Size Category	Heating Section Type		6/1/2011	6/1/2011	Test Procedure ^a
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 11.0 IEER	
	≥ 240,000 Btu/h and	Electric Resistance (or		10.0 EER	10.0 EER	
	< 760,000 Btu/h	None)	Single Package	10.1 IEER	10.1 IEER	
		All other	Split System and	9.8 EER	9.8 EER	
	50000 P		Single Package	9.9 IEER	9.9 IEER	
	≥760,000 Btu/h	Electric Resistance (or None)	Single Package	9.7 EER 9.8 IEER	9.7 EER 9.8 IEER	
		All other	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 9.6 IEER	
	< 65,000 Btu/h ^b	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER 11.7 IEER	12.1 EER 12.3 IEER	
	,	All other	Split System and Single Package	11.3 EER 11.5 IEER	11.9 EER 12.1 IEER	
Air conditioners, water	≥ 135,000 Btu/h and	Electric Resistance (or		11.0 EER	12.5 EER	AHRI 340/360
cooled	< 240,000 Btu/h	None)	Single Package	11.2 IEER	12.7 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	12.3 EER 12.5 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.4 EER 12.6 IEER	
		All other	Split System and	10.8 EER	12.2 EER	
	≥ 760,000 Btu/h	Electric Resistance (or	Single Package Split System and	10.9 IEER 11.0 EER	12.4 IEER 12.2 EER	
	2 700,000 Btu/II	None)	Single Package	11.0 EER 11.1 IEER	12.4 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.0 EER 12.2 IEER	
	< 65,000 Btu/h ^b	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)		11.5 EER 11.7 IEER	12.1 EER 12.3 IEER	
		All other	Split System and Single Package	11.3 EER 11.5 IEER	11.9 EER 12.1 IEER	
Air conditioners, evaporatively cooled	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)		11.0 EER 11.2 IEER	12.0 EER 12.2 IEER	AHRI 340/360
evaporari very coolea	(210,000 Btail	All other	Split System and Single Package	10.8 EER 11.0 IEER	11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and	Electric Resistance (or None)	Split System and	11.0 EER	11.9 EER	
	< 760,000 Btu/h	All other	Single Package Split System and	11.1 IEER 10.8 EER	12.1 IEER 12.2 EER	
	≥ 760,000 Btu/h	Electric Resistance (or	Single Package Split System and	10.9 IEER 11.0 EER	11.9 IEER 11.7 EER	
		None) All other	Single Package Split System and	11.1 EER 10.8 EER	11.9 EER 11.5 EER	
Condensing units, air	≥ 135,000 Btu/h		Single Package	10.9 EER 10.1 EER	11.7 EER 10.5 EER	
cooled	·			11.4 IEER	11.8 IEER	A LID 1 2 6 5
Condensing units, water cooled	≥ 135,000 Btu/h			13.1 EER 13.6 IEER	13.5 EER 14.0 IEER	AHRI 365
Condensing units, evaporatively cooled	≥ 135,000 Btu/h			13.1 EER 13.6 IEER	13.5 EER 14.0 IEER	

For SI: 1 British thermal unit per hour = 0.2931 W.

^aChapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.

^bSingle-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by

NAECA.

Table C403.2.3(1)B Minimum Efficiency Requirements--Air Conditioners and Condensing Units Serving Computer Rooms

Equipment Type	Net Sensible Cooling		
	Capacity ^a	Efficiency Downflow Units/upflow Units	Test Procedure
Air conditioners, air cooled	< 65,000 Btu/h (< 19 kW)	2.20/2.09	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h (≥ 19 kW and < 70 kW)	2.10/1.99	
	$\geq 240,000 \text{ Btu/h} (\geq 70 \text{ kW})$	1.90/1.79	
Air conditioners, water cooled	< 65,000 Btu/h (< 19 kW)	2.60/2.49	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h (≥ 19 kW and < 70 kW)	2.50/2.39	
	$\geq 240,000 \text{ Btu/h} (\geq 70 \text{ kW})$	2.40/2.29	
Air conditioners, water cooled with fluid economizer	< 65,000 Btu/h (< 19 kW)	2.55/2.44	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h (≥ 19 kW and < 70 kW)	2.45/2.34	
	$\geq 240,000 \text{ Btu/h} (\geq 70 \text{ kW})$	2.35/2.24	
Air conditioners, glycol cooled (rated at 40% propylene glycol)	< 65,000 Btu/h (< 19 kW)	2.50/2.39	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h (≥ 19 kW and < 70 kW)	2.15/2.04	
	≥ 240,000 Btu/h (≥ 70 kW)	2.10/1.99	
Air conditioners, glycol cooled (rated at 40% propylene glycol) with fluid economizer	< 65,000 Btu/h (< 19 kW)	2.45/2.34	ANSI/ASHRAE 127
	≥ 65,000 Btu/h and < 240,000 Btu/h (≥ 19 kW and < 70 kW)	2.10/1.99	
	≥ 240,000 Btu/h (≥ 70 kW)	2.05/1.94	

^aNet sensible cooling capacity: The total gross cooling capacity less the latent cooling less the energy to the air movement

Table C403.2.3(1)C

system (Total Gross - Latent - Fan Power).

b Sensible coefficient of performance (SCOP-127): A ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheaters and humidifiers) at conditions defined in ASHRAE Standard 127. The net sensible cooling capacity is the gross sensible capacity minus the energy dissipated into the cooled space by the fan system.

Minimum Efficiency Requirements--Electrically Operated Variable Refrigerant Flow Air Conditioners

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
VRF Air Conditioners, Air Cooled	< 65,000 Btu/h	All	VRF Multi-Split System	13.0 SEER	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System	11.2 EER 13.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System	11.0 EER 12.9 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	10.0 EER 11.6 IEER	

Table C403.2.3(1)D
Minimum Efficiency Requirements--Electrically Operated Variable
Refrigerant Flow Air-to-Air and Applied Heat Pumps

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
VRF Air Cooled (cooling mode)	< 65,000 Btu/h	All	VRF Multi-Split System	13.0 SEER	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System	11.0 EER 12.9 IEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System with Heat Recovery	10.8 EER 12.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System	10.6 EER 12.3 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System with Heat Recovery	10.4 EER 12.1 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System	9.5 EER 11.0 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or none)	VRF Multi-Split System with Heat Recovery	9.3 EER 10.8 IEER	

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
VRF Water Source (cooling mode)	< 65,000 Btu/h	All	VRF Multi-Split System 86°F entering water	12.0 EER	AHRI 1230
	< 65,000 Btu/h	All	VRF Multi-Split System with Heat Recovery 86°F entering water	11.8 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	VRF Multi-Split System 86°F entering water	12.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery 86°F entering water	11.8 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System 86°F entering water	10.0 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery 86°F entering water	9.8 EER	
VRF Groundwater Source (cooling mode)	< 135,000 Btu/h	All	VRF Multi-Split System 59°F entering water	16.2 EER	AHRI 1230
	< 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery 59°F entering water	16.0 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System 59°F entering water	13.8 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery 59°F entering water	13.6 EER	
VRF Ground Source (cooling mode)	< 135,000 Btu/h	All	VRF Multi-Split System 77°F entering water	13.4 EER	AHRI 1230

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
V	< 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery 77°F entering water	13.2 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System 77°F entering water	11.0 EER	
	≥ 135,000 Btu/h	All	VRF Multi-Split System with Heat Recovery 77°F entering water	10.8 EER	
VRF Air Cooled (heating mode)	< 65,000 Btu/h (cooling capacity)		VRF Multi-Split System	7.7 HSPF	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)		VRF Multi-Split System 47°F db/43°F wb outdoor air 17°F db/15°F wb outdoor air	3.3 COP 2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)		VRF Multi-Split System 47°F db/43°F wb outdoor air 17°F db/15°F wb outdoor air	3.2 COP 2.05 COP	
VRF Water Source (heating mode)	<135,000 Btu/h (cooling capacity)		VRF Multi-Split System 68°F entering water	4.2 COP	AHRI 1230
	≥ 135,000 Btu/h (cooling capacity)		VRF Multi-Split System 68°F entering water	3.9 COP	
VRF Groundwater Source (heating mode)	< 135,000 Btu/h (cooling capacity)		VRF Multi-Split System 50°F entering water	3.6 COP	AHRI 1230
	≥ 135,000 Btu/h (cooling capacity)		VRF Multi-Split System 50°F entering water	3.3 COP	
VRF Ground Source (heating mode)	<135,000 Btu/h (cooling capacity)		VRF Multi-Split System 32°F entering water	3.1 COP	AHRI 1230

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
	≥ 135,000 Btu/h (cooling capacity)		VRF Multi-Split System 32°F entering water	2.8 COP	

WAC 51-11-403232 Table C403.2.3(2)--Minimum efficiency requirements--Electrically operated unitary and applied heat pumps.

Table C403.2.3(2)
Minimum Efficiency Requirements--Electrically Operated Unitary and Applied Heat Pumps

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure ^a
Air cooled (cooling mode)	< 65,000 Btu/h ^b	All	Split System	13.0 SEER	AHRI 210/240
			Single Packaged	13.0 SEER	
Through-the-wall, air cooled (cooling mode)	≤ 30,000 Btu/h ^b	All	Split System	12.0 SEER	
			Single Packaged	12.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	AHRI 340/360
		All Other	Split System and Single Package	10.8 EER 11.0 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER 10.7 IEER	
		All Other	Split System and Single Package	10.4 EER 10.5 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 9.6 IEER	
		All Other	Split System and Single Package	9.3 EER 9.4 IEER	
Water source (cooling mode)	< 17,000 Btu/h	All	86°F entering water	11.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	12.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	12.0 EER	
Ground water source (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.2 EER	
Ground water source (cooling mode)	< 135,000 Btu/h	All	77°F entering water	13.4 EER	
Water-source water to water (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	ISO 13256-2

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure ^a
			59°F entering water	16.3 EER	
Ground water source brine to water (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	
Air cooled (heating mode)	< 65,000 Btu/h ^b	_	Split System	7.7 HSPF	AHRI 210/240
		_	Single Package	7.7 HSPF	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/hb (cooling capacity)	_	Split System	7.4 HSPF	
		_	Single Package	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h ^b	_	Split System	6.8 HSPF	
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	_	47°F db/43°F wb Outdoor Air	3.3 COP	AHRI 340/360
			17°F db/15°F wb Outdoor Air	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	_	47°F db/43°F wb Outdoor Air	3.2 COP	
			17°F db/15°F wb Outdoor Air	2.05 COP	
Water source (heating mode)	< 135,000 Btu/h (cooling capacity)	_	68°F entering water	4.2 COP	ISO 13256-1
Ground water source (heating mode)	< 135,000 Btu/h (cooling capacity)	_	50°F entering water	3.6 COP	
Ground source (heating mode)	< 135,000 Btu/h (cooling capacity)	_	32°F entering fluid	3.1 COP	
Water-source water to water (heating mode)	< 135,000 Btu/h (cooling capacity)	_	68°F entering water	3.7 COP	ISO 13256-2
			50°F entering water	3.1 COP]
Ground source brine to water (heating mode)	< 135,000 Btu/h (cooling capacity)	_	32°F entering fluid	2.5 COP	

For SI: 1 British thermal unit per hour = 0.2931 W, $^{\circ}$ C = [($^{\circ}$ F) - 32]/1.8.

NEW SECTION

WAC 51-11C-403233 Table C403.2.3(3)--Minimum efficiency requirements--Electrically operated PTAC, PTHP, SPVAC, SPVHP, room air conditioners.

Table C403.2.3(3) Minimum Efficiency Requirements--Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-

^aChapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.

year version of the test procedure.

^bSingle-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

Package Vertical Heat Pumps, Room Air Conditioners and Room Air-Conditioner Heat Pumps

			Minimum	Efficiency	
Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Before 10/08/2012	As of 10/08/2012	Test Procedure ^a
PTAC (cooling mode)	All Capacities	95°F db outdoor air	12.5 - (0.213 ×	13.8 - (0.300 ×	AHRI 310/380
new construction PTAC (cooling mode)	All Capacities	95°F db outdoor air	Cap/1000) EER 10.9 - (0.213 ×	Cap/1000) EER 10.9 - (0.213 ×	
replacements ^b	An Capacities	93 F do outdoor air	Cap/1000) EER	Cap/1000) EER	
PTHP (cooling mode) new construction	All Capacities	95°F db outdoor air	12.3 - (0.213 × Cap/1000) EER	14.0 - (0.300 × Cap/1000) EER	
PTHP (cooling mode) replacements ^b	All Capacities	95°F db outdoor air	10.8 - (0.213 × Cap/1000) EER	10.8 - (0.213 × Cap/1000) EER	
PTHP (heating mode) new construction	All Capacities		3.2 - (0.026 × Cap/1000) COP	3.7 - (0.052 × Cap/1000) COP	
PTHP (heating mode) replacements ^b	All Capacities	ĺ	2.9 - (0.026 × Cap/1000) COP	2.9 - (0.026 × Cap/1000) COP	
SPVAC (cooling mode)	< 65,000 Btu/h	95°F db/75°F wb outdoor air	9.0 EER	9.0 EER	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	95°F db/75°F wb outdoor air	8.9 EER	8.9 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	95°F db/75°F wb outdoor air	8.6 EER	8.6 EER	
SPVHP (cooling mode)	< 65,000 Btu/h	95°F db/75°F wb outdoor air	9.0 EER	9.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	95°F db/75°F wb outdoor air	8.9 EER	8.9 EER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	95°F db/75°F wb outdoor air	8.6 EER	8.6 EER	
SPVHP (heating mode)	<65,000 Btu/h	47°F db/43°F wb outdoor air	3.0 COP	3.0 COP	AHRI 390
	≥ 65,000 Btu/h and < 135,000 Btu/h	47°F db/43°F wb outdoor air	3.0 COP	3.0 COP	
	≥ 135,000 Btu/h and < 240,000 Btu/h	47°F db/43°F wb outdoor air	2.9 COP	2.9 COP	
Room air conditioners, with louvered sides	< 6,000 Btu/h	_	9.7 SEER	9.7 SEER	ANSI/AHA-MRAC-1
	≥ 6,000 Btu/h and < 8,000 Btu/h	_	9.7 EER	9.7 EER	
	≥ 8,000 Btu/h and < 14,000 Btu/h	_	9.8 EER	9.8 EER	
	≥ 14,000 Btu/h and < 20,000 Btu/h	_	9.7 SEER	9.7 SEER	
	≥ 20,000 Btu/h	_	8.5 EER	8.5 EER	
Room air conditioners, without louvered sides	< 8,000 Btu/h	_	9.0 EER	9.0 EER	
	≥ 8,000 Btu/h and < 20,000 Btu/h	_	8.5 EER	8.5 EER	
	≥ 20,000 Btu/h	_	8.5 EER	8.5 EER	
Room air-conditioner heat pumps with louvered sides	< 20,000 Btu/h	_	9.0 EER	9.0 EER	

			Minimum Efficiency		
Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Before 10/08/2012	As of 10/08/2012	Test Procedure ^a
	≥ 20,000 Btu/h		8.5 EER	8.5 EER	
Room air-conditioner heat pumps without louvered sides	< 14,000 Btu/h	1	8.5 EER	8.5 EER	
	≥ 14,000 Btu/h		8.0 EER	8.0 EER	
Room air conditioner casement only	All capacities	1	8.7 EER	8.7 EER	
Room air conditioner casement-slider	All capacities		9.5 EER	9.5 EER	

For SI: 1 British thermal unit per hour = 0.2931 W, $^{\circ}$ C = [($^{\circ}$ F) - 32]/1.8.

NEW SECTION

WAC 51-11C-403234 Table C403.2.3(4)--Minimum efficiency requirements--Warm air furnaces and unit heaters.

Table 403.2.3(4)

Warm Air Furnaces and Combination Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces and Unit Heaters, Minimum Efficiency Requirements

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency ^{d, e}	Test Procedure ^a
Warm air furnaces, gas fired	< 225,000 Btu/h		78% AFUE or 80% <i>E</i> _t ^c	DOE 10 C.F.R. Part 430 or ANSI Z21.47
	≥ 225,000 Btu/h	Maximum capacity ^c	$80\% E_t^{ \mathrm{f}}$	ANSI Z21.47
Warm air furnaces, oil fired	< 225,000 Btu/h		78% AFUE or 80% <i>E</i> _t ^c	DOE 10 C.F.R. Part 430 or UL 727
	≥ 225,000 Btu/h	Maximum capacity ^b	$81\% E_t^g$	UL 727
Warm air duct furnaces, gas fired	All capacities	Maximum capacity ^b	$80\%~E_c$	ANSI Z83.8
Warm air unit heaters, gas fired	All capacities	Maximum capacity ^b	$80\%~E_c$	ANSI Z83.8
Warm air unit heaters, oil fired	All capacities	Maximum capacity ^b	$80\%~E_c$	UL 731

For SI: 1 British thermal unit per hour = 0.2931 W.

[13] OTS-4948.4

[&]quot;Cap" = The rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculations.

^aChapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

^bReplacement unit shall be factory labeled as follows: "MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW STANDARD PROJECTS" or "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) in height and less than 42 inches (1067 mm) in width.

^aChapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

^bMinimum and maximum ratings as provided for and allowed by the unit's controls.

^cCombination units not covered by the National Appliance Energy Conservation Act of 1987 (NAECA) (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]) shall comply with either rating.

 $^{^{}d}E_{t}$ = Thermal efficiency. See test procedure for detailed discussion.

 $^{^{\}rm e}E_{\rm c}$ = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.

- $^{\mathrm{f}}E_{c}=$ Combustion efficiency. Units must also include an IID, have jackets not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
- Thermal efficiency. Units must also include an IID, have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

WAC 51-11C-403235 Table C403.2.3(5)--Minimum efficiency requirements--Gas- and oil-fired boilers.

Table C403.2.3(5)
Minimum Efficiency Requirements--Gas- and Oil-Fired Boilers

Equipment Type ^a	Subcategory or Rating Condition	Size Category (Input)	Minimum Efficiency	Test Procedure
Boilers, hot water	Gas-fired	< 300,000 Btu/h	80% AFUE	10 C.F.R. Part 430
		$\geq 300,000 \text{ Btu/h} \text{ and} \\ \leq 2,500,000 \text{ Btu/h}^b$	80% E _t	10 C.F.R. Part 431
		> 2,500,000 Btu/h ^a	$82\%~E_c$	
	Oil-fired ^c	< 300,000 Btu/h	80% AFUE	10 C.F.R. Part 430
		$\geq 300,000 \text{ Btu/h} \text{ and} \\ \leq 2,500,000 \text{ Btu/h}^b$	82% E _t	10 C.F.R. Part 431
		> 2,500,000 Btu/h ^a	$84\%~E_c$	
Boilers, steam	Gas-fired	< 300,000 Btu/h	75% AFUE	10 C.F.R. Part 430
	Gas-fired - All, except natural draft	$\geq 300,000 \text{ Btu/h} \text{ and} \\ \leq 2,500,000 \text{ Btu/h}^b$	79% E _t	10 C.F.R. Part 431
		> 2,500,000 Btu/h ^a	79% E _t	
	Gas-fired-natural draft	$\geq 300,000 \text{ Btu/h} \text{ and} \\ \leq 2,500,000 \text{ Btu/h}^b$	77% E _t	
		> 2,500,000 Btu/h ^a	77% E _t	
	Oil-fired ^c	< 300,000 Btu/h	80% AFUE	10 C.F.R. Part 430
		$\geq 300,000 \text{ Btu/h} \text{ and} \\ \leq 2,500,000 \text{ Btu/h}^b$	81% E _t	10 C.F.R. Part 431
		> 2,500,000 Btu/h ^a	81% E _t	

For SI: 1 British thermal unit per hour = 0.2931 W.

 E_c = Combustion efficiency (100 percent less flue losses).

 E_t = Thermal efficiency. See referenced standard document for detailed information.

^aThese requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

^bMaximum capacity minimum and maximum ratings as provided for and allowed by the unit's controls.

^cIncludes oil-fired (residual).

WAC 51-11C-403236 Table C403.2.3(6)--Reserved.

Table C403.2.3(6)

Reserved

NEW SECTION

WAC 51-11C-403237 Table C403.2.3(7)--Minimum efficiency requirements--Water chilling packages.

Table C403.2.3(7)
Minimum Efficiency Requirements--Water Chilling Packages^a

					As of 1/1/2010 ^b				
			Before	1/1/2010	Pa	th A	Pat	h B	
							Full		
Equipment Type	Size Category	Units	Full Load	IPLV	Full Load	IPLV	Load	IPLV	Test Procedure ^c
Air cooled chillers	< 150 tons	EER	≥ 9.562	≥10.416	≥ 9.562	≥ 12.500	NA	NA	AHRI 550/590
	≥ 150 tons	EER			≥ 9.562	≥ 12.750	NA	NA	
Air cooled without	All capacities	EER	≥ 10.586	≥ 11.782		illers without o			
condenser, electrical						atching conden		omply	
operated						ooled chiller ef	ficiency		
					requirements				
Water cooled,	All capacities	kW/ton	≤ 0.837	≤ 0.696		g units shall co			
electrically operated,						ve displacemen	t efficienc	ey .	
reciprocating					requirements				
Water cooled,	< 75 tons	kW/ton	≤ 0.790	≤ 0.676	≤ 0.780	≤ 0.630	≤ 0.800	≤ 0.600	
electrically operated,									
positive displacement									
	≥75 tons and	kW/ton			≤ 0.775	≤ 0.615	≤ 0.790	≤ 0.586	
	< 150 tons								
	≥ 150 tons and	kW/ton	≤ 0.717	≤ 0.627	≤ 0.680	≤ 0.580	≤ 0.718	≤ 0.540	
	< 300 tons								
	≥ 300 tons	kW/ton	≤ 0.639	≤ 0.571	≤ 0.620	≤ 0.540	≤ 0.639		
Water cooled,	< 150 tons	kW/ton	≤ 0.703	≤ 0.669	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450	
electrically operated,									
centrifugal									
	≥ 150 tons and	kW/ton	≤ 0.634	≤ 0.596					
	< 300 tons								
	\geq 300 tons and	kW/ton	≤ 0.576	≤ 0.549	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400	
	< 600 tons								
	≥600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400	
Air cooled, absorption	All capacities	COP	≥ 0.600	NR	≥ 0.600	NR	NA	NA	AHRI 560
single effect									
Water cooled, absorption	All capacities	COP	≥ 0.700	NR	≥ 0.700	NR	NA	NA	
single effect									
Absorption double	All capacities	COP	≥ 1.000	≥ 1.050	≥1.000	≥ 1.050	NA	NA	
effect, indirect fired									
Absorption double	All capacities	COP	≥ 1.000	≥ 1.000	≥ 1.000	≥ 1.000	NA	NA	
effect, direct fired									

For SI: 1 ton = 3517 W, 1 British thermal unit per hour = 0.2931 W, $^{\circ}$ C = [($^{\circ}$ F) - 32]/1.8.

NA = Not applicable, not to be used for compliance;

NR = No requirement.

^a The centrifugal chiller equipment requirements, after adjustment in accordance with Section C403.2.3.1 or Section C403.2.3.2, do not apply to chillers used in low-temperature applications where the design leaving fluid temperature is less than 36°F. The requirements do not apply to positive displacement chillers with leaving fluid temperatures less than or equal to 32°F. The requirements do not apply to absorption chillers with design leaving fluid temperatures less than 40°F.

WAC 51-11C-403238 Table C403.2.3(8)--Minimum efficiency requirements--Heat rejection equipment.

Table C403.2.3(8)
Minimum Efficiency Requirements--Heat Rejection Equipment

Equipment Type ^a	Total System Heat Rejection Capacity at Rated Conditions	Subcategory or Rating Condition	Performance Required ^{b, c, d}	Test Procedure ^{e, f}
Propeller or axial fan open circuit cooling towers	All	95°F Entering Water 85°F Leaving Water 75°F Entering wb	≥ 38.2 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal fan open circuit cooling towers	All	95°F Entering Water 85°F Leaving Water 75°F Entering wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Propeller or axial fan closed circuit cooling towers	All	102°F Entering Water 90°F Leaving Water 75°F Entering wb	≥ 14.0 gpm/hp	CTI ATC-105S and CTI STD-201
Centrifugal closed circuit cooling towers	All	102°F Entering Water 90°F Leaving Water 75°F Entering wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201
Air cooled condensers	All	125°F Condensing Temperature R-22 Test Fluid 190°F Entering Gas Temperature 15°F Subcooling 95°F Entering db	≥ 176,000 Btu/h • hp	AHRI 460

For SI: ${}^{\circ}\text{C} = [({}^{\circ}\text{F}) - 32]/1.8$, L/s \bullet kW = (gpm/hp)/(11.83), COP = (Btu/h \bullet hp)/(2550.7).

db = dry bulb temperature, °F;

wb = wet bulb temperature, °F.

^b Compliance with this standard can be obtained by meeting the minimum requirements of Path A or B. However, both the full load and IPLV shall be met to fulfill the requirements of Path A or B.

^c Chapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

^a The efficiencies and test procedures for both open and closed circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of wet and dry heat exchange sections.

^b For purposes of this table, open circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 403.2.3(8) divided by the fan nameplate rated motor power.

^c For purposes of this table, closed circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table 403.2.3(8) divided by the sum of the fan nameplate rated motor power and the spray pump nameplate rated motor power.

^dFor purposes of this table, air cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.

^eChapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

If a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, then the product shall be listed in the certification program, or, if a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, but the product is not listed in the existing certification program, the ratings shall be verified by an independent laboratory test report.

WAC 51-11C-403239 Table C403.2.3(9)--Minimum efficiency requirements--Heat transfer equipment.

Table C403.2.3(9) Heat Transfer Equipment

Equipment	Subcategory	Minimum	Test
Type		Efficiency	Procedure ^a
Liquid-to-liquid heat exchangers	Plate type	NR	AHRI 400

NR = No requirement.

^aChapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

NEW SECTION

WAC 51-11C-40324 Section C403.2.4--HVAC system controls.

C403.2.4 HVAC system controls. Each heating and cooling system shall be provided with thermostatic controls as specified in Section C403.2.4.1, C403.2.4.2, C403.2.4.3, C403.2.4.4, C403.4.1, C403.4.2, C403.4.3, C403.4.4, C403.4.5, C403.4.6, C403.4.7, C403.4.8, C403.4.9, or C403.4.10.

NEW SECTION

WAC 51-11C-403241 Section C403.2.4.1--Thermostatic controls.

C403.2.4.1 Thermostatic controls. The supply of heating and cooling energy to each zone shall be controlled by individual thermostatic controls capable of responding to temperature within the zone. At a minimum, each floor of a building shall be considered as a separate zone. Controls on systems required to have economizers and serving single zones shall have multiple cooling stage capability and activate the economizer when appropriate as the first stage of cooling. See Section C403.3.1 or C403.4.1 for further economizer requirements. Where humidification or dehumidification or both is provided, at least one humidity control device shall be provided for each humidity control system.

EXCEPTION:

Independent perimeter systems that are designed to offset only building envelope heat losses or gains or both serving one or more perimeter *zones* also served by an interior system provided:

1. The perimeter system includes at least one thermostatic control zone for each building exposure having exterior walls facing only one orientation (within +/-45 degrees) (0.8 rad) for more than 50 contiguous feet (15,240 mm); and

[17] OTS-4948.4

2. The perimeter system heating and cooling supply is controlled by a thermostat located within the *zones* served by the system.

C403.2.4.1.1 Heat pump supplementary heat. Unitary air cooled heat microprocessor controls that shall include minimize supplemental heat usage during start-up, set-up, and defrost conditions. These controls shall anticipate need for heat and use compression heating as the first stage of heat. Controls shall indicate when supplemental heating is being used through visual (e.q., LED indicators). Heat pumps equipped with supplementary heaters shall be installed with controls that prevent supplemental heater operation above 40°F.

EXCEPTION:

Packaged terminal heat pumps (PTHPs) of less than 2 tons $(24,000\,\text{Btu/hr})$ cooling capacity provided with controls that prevent supplementary heater operation above 40°F .

NEW SECTION

WAC 51-11C-403242 Section C403.2.4.2--Setpoint overlap restriction.

C403.2.4.2 Setpoint overlap restriction. Where used to control both heating and cooling, *zone* thermostatic controls shall provide a temperature range or deadband of at least 5°F (2.8°C) within which the supply of heating and cooling energy to the *zone* is capable of being shut off or reduced to a minimum.

EXCEPTION:

Thermostats requiring manual changeover between heating and cooling modes.

NEW SECTION

WAC 51-11C-403243 Section C403.2.4.3--Off-hour controls.

C403.2.4.3 Off-hour controls. For all occupancies other than Group R, each *zone* shall be provided with thermostatic setback controls that are controlled by either an automatic time clock or programmable control system.

EXCEPTIONS:

- 1. Zones that will be operated continuously.
- 2. Zones with a full HVAC load demand not exceeding 6,800 Btu/h (2 kW) and having a readily accessible manual shutoff switch.
- **C403.2.4.3.1 Thermostatic setback capabilities.** Thermostatic setback controls shall have the capability to set back or temporarily operate the system to maintain *zone* temperatures down to $55^{\circ}F$ (13°C) or up to $85^{\circ}F$ (29°C).
- C403.2.4.3.2 Automatic setback and shutdown capabilities.

Automatic time clock or programmable controls shall be capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for at least 10 hours. Additionally, the controls shall have a manual override that allows temporary operation of the system for up to 2 hours; a manually operated timer capable of being adjusted to operate the system for up to 2 hours; or an occupancy sensor.

C403.2.4.3.3 Automatic start capabilities. Automatic start controls shall be provided for each HVAC system. The controls shall be capable of automatically adjusting the daily start time of the HVAC system in order to bring each space to the desired occupied temperature immediately prior to scheduled occupancy.

NEW SECTION

WAC 51-11C-403244 Section C403.2.4.4--Shutoff damper controls.

C403.2.4.4 Shutoff damper controls. Both outdoor air supply and exhaust ducts shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use or during building warm-up, cooldown, and setback.

EXCEPTIONS:

- $1.\ Gravity\ relief\ dampers\ serving\ systems\ less\ than\ 5,000\ cfm\ total\ supply\ shall\ be\ permitted\ in\ buildings\ less\ than\ three\ stories\ in\ height.$
- $2. \ Gravity \ dampers \ shall \ be \ permitted \ for \ buildings \ of \ any \ height \ located \ in \ Climate \ Zones \ 1, \ 2 \ and \ 3.$
- 3. Gravity (nonmotorized) dampers in Group R occupancies where the design outdoor air intake or exhaust capacity does not exceed 400 cfm (189 L/s).
- 4. Systems serving areas which require continuous operation.
- 5. Combustion air intakes.
- 6. Operation of dampers shall be allowed during ventilation prepurge one hour before expected occupancy and for unoccupied period precooling during the cooling season.
- 7. Dampers are not required in systems where specifically prohibited by the *International Mechanical Code*.

NEW SECTION

WAC 51-11C-403245 Section C403.2.4.5--Snowmelt system controls.

C403.2.4.5 Snow melt system controls. Snow- and ice-melting systems, supplied through energy service to the building, shall include automatic controls capable of shutting off the system when the pavement temperature is above 50°F (10°C) and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F (4°C) so that the potential for snow or ice accumulation is negligible.

WAC 51-11C-403246 Section C403.2.4.6--Combustion heating equipment controls.

C403.2.4.6 Combustion heating equipment controls. Combustion heating equipment with a capacity over 225,000 Btu/h shall have modulating or staged combustion control.

EXCEPTIONS:

- 1. Boilers.
- 2. Radiant heaters.

NEW SECTION

WAC 51-11C-403247 Section C403.2.4.7--Hotel/motel controls.

- **C403.2.4.7 Group R-1 hotel/motel guest rooms.** For hotel and motel guest rooms, a minimum of one of the following control technologies shall be required in hotels/motels with over 50 guest rooms such that the space temperature would automatically setback (winter) or set up (summer) by no less than 5°F (3°C) or hotel and motel guest rooms, a minimum of:
- 1. Controls that are activated by the room occupant via the primary room access method Key, card, deadbolt, etc.
- 2. Occupancy sensor controls that are activated by the occupant's presence in the room.

NEW SECTION

WAC 51-11C-403248 Section C403.2.4.8--Residential occupancy controls.

C403.2.4.8 Group R-2 and R-3 dwelling units. The primary space conditioning system within each dwelling unit shall be provided with at least one programmable thermostat for the regulation of space temperature. The thermostat shall allow for, at a minimum, a 5-2 programmable schedule (weekdays/weekends) and be capable of providing at least two programmable setback periods per day.

Each additional system provided within the dwelling unit shall be provided with at least one adjustable thermostat for the

regulation of temperature.

EXCEPTIONS:

- 1. Systems controlled by an occupant sensor that is capable of shutting the system off when no occupant is sensed for a period of up to 30 minutes.
- 2. Systems controlled solely by a manually operated timer capable of operating the system for no more than two hours
- 3. Ductless heat pumps.

Each thermostat shall be capable of being set by adjustment or selection of sensors as follows: When used to control heating only: $55^{\circ}F$ to $75^{\circ}F$; when used to control cooling only: $70^{\circ}F$ to $85^{\circ}F$.

C403.2.4.9 Group R-2 sleeping units. The primary space conditioning system within each sleeping unit shall be provided with at least one programmable thermostat for the regulation of space temperature. The thermostat shall allow for, at a minimum, a 5-2 programmable schedule (weekdays/weekends) and be capable of providing at least two programmable setback periods per day.

Each additional system provided within the sleeping unit shall be provided with at least one adjustable thermostat for the regulation of temperature.

EXCEPTIONS:

- 1. Systems controlled by an occupant sensor that is capable of shutting the system off when no occupant is sensed for a period of up to 30 minutes.
- 2. Systems controlled solely by a manually operated timer capable of operating the system for no more than two hours.
- $3. \textit{Zones} \text{ with a full HVAC load demand not exceeding } 3,400 \; \text{Btu/h} \; (1 \; \text{kW}) \; \text{and having a readily accessible manual shutoff switch.}$
- 4. Ductless heat pumps.

Each thermostat shall be capable of being set by adjustment or selection of sensors as follows: When used to control heating only: $55^{\circ}F$ to $75^{\circ}F$; when used to control cooling only: $70^{\circ}F$ to $85^{\circ}F$.

NEW SECTION

WAC 51-11C-403249 Section C403.2.4.9--Direct digital control system capabilities.

- C403.2.4.10 Direct digital control system capabilities. All complex systems equipped with direct digital control (DDC) systems and all buildings with total cooling capacity exceeding 780,000 Btu/h (2,662 kW) shall have the following capability:
- 1. Trending: All control system input and output points shall be accessible and programmed for trending, and a graphic trending package shall be provided with the control system.
- 2. Demand Response Setpoint Adjustment: Control logic shall increase the cooling zone set points by at least 2°F (1°C) and reduce the heating zone set points by at least 2°F (1°C) when activated by a demand response signal. The demand response signal shall be a binary input to the control system or other interface approved by the serving electric utility.

WAC 51-11C-40325 Section C403.2.5--Ventilation.

C403.2.5 Ventilation. Ventilation, either natural or mechanical, shall be provided in accordance with Chapter 4 of the *International Mechanical Code*. Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by Chapter 4 of the *International Mechanical Code*.

NEW SECTION

WAC 51-11C-403251 Section C403.2.5.1--Demand control ventilation.

C403.2.5.1 Demand controlled ventilation. Demand control ventilation (DCV) shall be provided for spaces larger than 500 square feet (50 m^2) and with an occupant load greater than 25 people per 1000 square feet (93 m^2) of floor area (as established in Table 403.3 of the *International Mechanical Code*) and served by systems with one or more of the following:

- 1. An air-side economizer;
- 2. Automatic modulating control of the outdoor air damper; or
- 3. A design outdoor airflow greater than 3,000 cfm (1400 L/s).

EXCEPTION:

Demand control ventilation is not required for systems and spaces as follows:

- 1. Systems with energy recovery complying with Section C403.2.6.
- 2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.
- 3. System with a design outdoor airflow less than 1,000 cfm (472 L/s).
- 4. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (600 L/s).
- 5. Ventilation provided for process loads only.

NEW SECTION

WAC 51-11C-403252 Section C403.2.5.2--Occupancy sensors.

C403.2.5.2 Occupancy sensors. Classrooms, gyms, auditoriums and conference rooms larger than 500 square feet of floor area shall have occupancy sensor control that will either close outside air

dampers or turn off serving equipment when the space is unoccupied except where equipped with another means to automatically reduce outside air intake below design rates when spaces are partially occupied.

NEW SECTION

WAC 51-11C-403253 Section C403.2.5.3--Loading dock and parking garage ventilation system controls.

C403.2.5.3 Enclosed loading dock and parking garage exhaust ventilation system control. Mechanical ventilation systems for enclosed loading docks and parking garages shall be designed to exhaust the airflow rates (maximum and minimum) determined in accordance with the *International Mechanical Code*.

Ventilation systems shall be equipped with a control device that operates the system automatically upon detection of vehicle operation or the presence of occupants by approved automatic detection devices. Each of the following types of controllers shall be capable of shutting off fans or modulating fan speed. Control devices shall not reduce airflow rates below the minimum requirement in accordance with the *International Mechanical Code* during scheduled periods of occupied operation.

- 1. Gas sensor controllers used to activate the exhaust ventilation system shall stage or modulate fan speed upon detection of specified gas levels. All equipment used in sensor controlled systems shall be designed for the specific use and installed in accordance with the manufacturer's recommendations. The system shall be arranged to operate automatically by means of carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors. Garages and loading docks shall be equipped with a controller and a full array of carbon monoxide (CO) sensors set to maintain levels of carbon monoxide below 35 parts per million (ppm). Additionally, a full array of nitrogen dioxide detectors shall be connected to the controller set to maintain the nitrogen dioxide level below the OSHA standard for eight hour exposure. Spacing and location of the sensors shall be installed in accordance with manufacturer recommendations.
- 2. Occupant detection sensors used to activate the system shall detect entry into the parking garage along both the vehicle and pedestrian pathways.
- **C403.2.5.3.1 System activation devices for enclosed loading docks.** Ventilation systems for enclosed loading docks shall be activated by one of the following:
- 1. Gas sensors installed in accordance with the *International Mechanical Code*; or
- 2. Occupant detection sensors used to activate the system that detects entry into the loading area along both the vehicle and

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pedestrian pathways.

C403.2.5.3.2 System activation devices for enclosed parking garages. Ventilation systems for enclosed parking garages shall be activated by gas sensors.

EXCEPTION:

A parking garage ventilation system having a total design capacity under 8,000 cfm may use occupant sensors.

NEW SECTION

WAC 51-11C-403254 Section C403.2.5.4--Exhaust systems.

C403.2.5.4 Exhaust systems.

C403.2.5.4.1 Kitchen hoods. Each kitchen area with total exhaust capacity larger than 2,000 cfm shall be provided with make-up air sized so that at least 50% of exhaust air volume be (a) unheated or heated to no more than 60%F and (b) uncooled or cooled without the use of mechanical cooling.

EXCEPTIONS:

- 1. Where hoods are used to exhaust ventilation air which would otherwise exfiltrate or be exhausted by other fan systems. A detailed accounting of exhaust airflows shall be provided on the plans that accounts for the impact of any required demand controlled ventilation.
- 2. Certified grease extractor hoods that require a face velocity no greater than 60 fpm.

C403.2.5.4.2 Laboratory exhaust systems. Buildings with laboratory exhaust systems having a total exhaust rate greater than 5,000 cfm (2,360 L/s) shall include heat recovery systems to preconditioned makeup air from laboratory exhaust. The heat recovery system shall be capable of increasing the outside air supply temperature at design heating conditions by 25°F (13.9°C) in Climate Zones 4C/5B and 35°F (19.4°C) in Climate Zone 6B. A provision shall be made to bypass or control the heat recovery system to permit air economizer operation as required by Section C403.4.

EXCEPTIONS:

- $1.\ Variable\ air\ volume\ laboratory\ exhaust\ and\ room\ supply\ systems\ capable\ of\ reducing\ exhaust\ and\ make-up\ air\ volume\ to\ 50\%\ or\ less\ of\ design\ values;\ or$
- 2. Direct make-up (auxiliary) air supply equal to at least 75% of the exhaust rate, heated no warmer than $2^{\circ}F$ (1.1°C) below room set point, cooled to no cooler than $3^{\circ}F$ (1.7°C) above room set point, no humidification added, and no simultaneous heating and cooling used for dehumidification control; or
- 3. Combined Energy Reduction Method: VAV exhaust and room supply system capable of reducing exhaust and makeup air volumes and a heat recovery system to precondition makeup air from laboratory exhaust that when combined will produce the same energy reduction as achieved by a heat recovery system with a 50% sensible recovery effectiveness as required above. For calculation purposes, the heat recovery component can be assumed to include the maximum design supply airflow rate at design conditions. The combined energy reduction (Q_{ER}) shall meet the following:

$$Q_{ER} \geq Q_{MIN}$$

$$Q_{MIN} = CFM_S \bullet (T_R - T_O) \bullet 1.1 \bullet 0.6$$

$$Q_{ER} = CFM_S \bullet (T_R - T_O) \bullet 1.1(A + B)/100$$

Where:

 Q_{MIN} = Energy recovery at 60% sensible

effectiveness (Btu/h)

 Q_{ER} = Combined energy reduction (Btu/h)

CFM_s = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute

T_R = Space return air dry bulb at winter design conditions

T_o = Outdoor air dry bulb at winter design conditions

A = Percentage that the exhaust and makeup air volumes can be reduced from design conditions

B = Percentage sensible heat recovery effectiveness

NEW SECTION

WAC 51-11C-40326 Section C403.2.6--Energy recovery.

C403.2.6 Energy recovery.

C403.2.6.1 Energy recovery ventilation systems. Any system with minimum outside air requirements at design conditions greater than 5,000 CFM or any system required by Table C403.2.6 shall include an energy recovery system. The energy recovery system shall have the capability to provide a change in the enthalpy of the outdoor air supply of not less than 50 percent of the difference between the outdoor air and return air enthalpies, at design conditions. Where an air economizer is required, the energy recovery system shall include a bypass or controls which permit operation of the economizer as required by Section C403.4. Where a single room or space is supplied by multiple units, the aggregate ventilation (cfm) of those units shall be used in applying this requirement.

EXCEPTION:

An energy recovery ventilation system shall not be required in any of the following conditions:

- 1. Where energy recovery systems are prohibited by the *International Mechanical Code*.
- 2. Laboratory fume hood systems that include at least one of the following features:
- 2.1. Variable-air-volume hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50 percent or less of design values.
- 2.2. Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than $2^{\circ}F$ (1.1°C) above room setpoint, cooled to no cooler than $3^{\circ}F$ (1.7°C) below room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
- 3. Systems serving spaces that are heated to less than 60°F (15.5°C) and are not cooled.
- 4. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
- 5. Heating energy recovery in Climate Zones 1 and 2.
- 6. Cooling energy recovery in Climate Zones 3C, 4C, 5B, 5C, 6B, 7 and 8.
- 7. Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
- 8. Multi-zone systems with cold deck supply air and zone reheat where the minimum outdoor air is less than 70 percent of total supply air.
- 9. Systems serving residential multifamily spaces where the largest source of air exhausted at a single location at the building exterior is less than 25 percent of the design outdoor air flow rate.
- **C403.2.6.2 Condensate systems.** On-site steam heating systems shall have condensate water heat recovery. On-site includes a system that is located within or adjacent to one or more buildings within the boundary of a contiguous area or campus under one ownership and

which serves one or more of those buildings.

Buildings using steam generated off-site with steam heating systems which do not have condensate water recovery shall have condensate water recovery.

C403.2.6.3 Condenser heat recovery. Facilities having food service, meat or deli departments and having 500,000 Btu/h or greater of remote refrigeration condensers shall have condenser waste heat recovery from freezers and coolers and shall use the waste heat for service water heating, space heating or for dehumidification reheat. Facilities having a gross conditioned floor area of 40,000 ft² or greater and 1,000,000 Btu/h or greater of remote refrigeration shall have condenser waste heat recovery from freezers and coolers and shall use the waste heat for service water heating, and either for space heating or for dehumidification reheat for maintaining low space humidity.

NEW SECTION

WAC 51-11C-403261 Table C403.2.6--Energy recovery requirement.

Table C403.2.6
Energy Recovery Requirement

	Percent (%) Outdoor Air at Full Design Airflow Rate					
Climate Zone	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
		Des	sign Supply Fan	Airflow Rate (cfm)	
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	≥5000	≥ 5000
1B, 2B, 5C	NR	NR	≥ 26000	≥ 12000	≥ 5000	≥ 4000
6B	≥ 11000	≥ 5500	≥ 4500	≥ 3500	≥ 2500	≥ 1500
1A, 2A, 3A, 4A, 5A, 6A	≥ 5500	≥ 4500	≥ 3500	≥ 2000	≥ 1000	>0
7, 8	≥ 2500	≥ 1000	> 0	> 0	> 0	>0

NR = Not required.

NEW SECTION

WAC 51-11C-40327 Section C403.2.7--Duct and plenum insulation and sealing.

C403.2.7 Duct and plenum insulation and sealing.

C403.2.7.1 Ducts, shafts and plenums conveying outside air from the exterior of the building to the mechanical system shall meet all air leakage and building envelope insulation requirements of Section C402, plus building envelope vapor control requirements from the *International Building Code*, extending continuously from the building exterior to an automatic shutoff damper or heating or cooling equipment. For the purposes of building envelope insulation requirements, duct surfaces shall meet the requirements for metal framed walls per Table C402.1.2. Duct surfaces included as part of the building envelope shall not be used in the calculation of maximum glazing area as described in Section 402.3.1.

EXCEPTIONS:

- 1. Outside air ducts serving individual supply air units with less than 2,800 cfm of total supply air capacity, provided these are insulated to R-7.
- 2. Unheated equipment rooms with combustion air louvers, provided they are isolated from conditioned space at sides, top and bottom of the room with R-11 nominal insulation.

C403.2.7.2 All other supply and return air ducts and plenums shall be insulated with a minimum of R-6 insulation where located in unconditioned spaces and a minimum of R-8 insulation where located outside the building. Where located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by minimum insulation value as required for exterior walls by Section C402.2.3.

EXCEPTIONS:

- 1. Where located within equipment.
- 2. Where the design temperature difference between the interior and exterior of the duct or plenum does not exceed $15^{\circ}F$ (8°C).

Supply ducts which convey supply air at temperatures less than 55°F or greater than 105°F shall be insulated with a minimum of R-3.3 insulation where located within conditioned space.

All ducts, air handlers, and filter boxes shall be sealed. Joints and seams shall comply with Section 603.9 of the International Mechanical Code.

- **C403.2.7.3 Duct construction.** Ductwork shall be constructed and erected in accordance with the *International Mechanical Code*.
- C403.2.7.3.1 Low-pressure duct systems. All longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 2 inches water gauge (w.g.) (500 Pa) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus embedded-fabric systems or tapes installed in accordance with the manufacturer's installation instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

EXCEPTION: Continuously welded and locking-type longitudinal joints and seams on ducts operating at static pressures less than 2 inches water gauge (w.g.) (500 Pa) pressure classification.

C403.2.7.3.2 Medium-pressure duct systems. All ducts and plenums designed to operate at a static pressure greater than 2 inches water gauge (w.g.) (500 Pa) but less than 3 inches w.g. (750 Pa) shall be insulated and sealed in accordance with Section C403.2.7. Pressure classifications specific to the duct system shall be

clearly indicated on the construction documents in accordance with the *International Mechanical Code*.

C403.2.7.3.3 High-pressure duct systems. Ducts designed to operate at static pressures in excess of 3 inches water gauge (w.g.) (750 Pa) shall be insulated and sealed in accordance with Section C403.2.7. In addition, ducts and plenums shall be leak-tested in accordance with the SMACNA HVAC Air Duct Leakage Test Manual with the rate of air leakage (CL) less than or equal to 6.0 as determined in accordance with Equation C4-5.

(Equation C4-5)

CL = F/P0.65

Where:

F = The measured leakage rate in cfm per 100 square feet of duct surface.

P = The static pressure of the test.

Documentation shall be furnished by the designer demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.

NEW SECTION

WAC 51-11C-40328 Section C403.2.8--Piping insulation.

C403.2.8 Piping insulation. All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table C403.2.8.

EXCEPTIONS:

- 1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
- 2. Factory-installed piping within room fan-coils and unit ventilators tested and rated according to AHRI 440 (except that the sampling and variation provisions of Section 6.5 shall not apply) and 840, respectively.
- 3. Piping that conveys fluids that have a design operating temperature range between $60^{\circ}F$ ($15^{\circ}C$) and $105^{\circ}F$ ($41^{\circ}C$).
- 4. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.
- 5. Strainers, control valves, and balancing valves associated with piping 1 inch (25 mm) or less in diameter.
- 6. Direct buried piping that conveys fluids at or below 60°F (15°C).

C403.2.8.1 Protection of piping insulation. Piping insulation exposed to weather shall be protected from damage, including that due to sunlight, moisture, equipment maintenance and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesives tape shall not be permitted.

WAC 51-11C-403281 Table C403.2.8--Minimum pipe insulation thickness.

Table C403.2.8

Minimum Pipe Insulation Thickness (thickness in inches)

Fluid Operating	Insulation Conductivity		Nominal Pipe or Tube Size (inches)				
Temperature Range and Usage (°F)	Conductivity Btu • in. /(h • ft² • °F) ^b	Mean Rating Temperature, °F	< 1	1 to < 1-1/2	1-1/2 to < 4	4 to < 8	≥ 8
> 350	0.32 - 0.34	250	4.5	5.0	5.0	5.0	5.0
251 - 350	0.29 - 0.32	200	3.0	4.0	4.5	4.5	4.5
201 - 250	0.27 - 0.30	150	2.5	2.5	2.5	3.0	3.0
141 - 200	0.25 - 0.29	125	1.5	1.5	2.0	2.0	2.0
105 - 140	0.21 - 0.28	100	1.0	1.0	1.5	1.5	1.5
40 - 60	0.21 - 0.27	75	0.5	0.5	1.0	1.0	1.0
< 40	0.20 - 0.26	75	0.5	1.0	1.0	1.0	1.5

^a For piping smaller than 1-1/2 inch (38 mm) and located in partitions within *conditioned spaces*, reduction of these thicknesses by 1 inch (25 mm) shall be permitted (before thickness adjustment required in footnote b) but not to a thickness less than 1 inch (25 mm).

 $T = r\{(1 + t/r)^{K/k} - 1\}$

Where:

T = Minimum insulation thickness,

r = Actual outside radius of pipe,

t = Insulation thickness listed in the table for applicable

fluid temperature and pipe size,

K = Conductivity of alternate material at mean rating temperature indicated for the applicable fluid

temperature indicated for the applicable fluitemperature (Btu \times in/h \times ft² \times °F) and

k = The upper value of the conductivity range listed in the table for the applicable fluid temperature.

NEW SECTION

WAC 51-11C-40329 Section C403.2.9--Mechanical system commissioning and completion requirements.

C403.2.9 Mechanical systems commissioning and completion requirements. Mechanical systems shall be commissioned and completed in accordance with Section C408.2.

^bFor insulation outside the stated conductivity range, the minimum thickness (*T*) shall be determined as follows:

^c For direct-buried heating and hot water system piping, reduction of these thicknesses by 1-1/2 inches (38 mm) shall be permitted (before thickness adjustment required in footnote b but not to thicknesses less than 1 inch (25 mm).

- WAC 51-11C-403291 Section C403.2.10--Air system design and control.
- C403.2.10 Air system design and control. Each HVAC system having a total fan system motor nameplate horsepower (hp) exceeding 5 horsepower (hp) (3.7 kW) shall meet the provisions of Sections C403.2.10.1 through C403.2.10.2.
- **C403.2.10.1 Allowable fan floor horsepower.** Each HVAC system at fan system design conditions shall not exceed the allowable *fan system motor nameplate hp* (Option 1) or *fan system bhp* (Option 2) as shown in Table C403.2.10.1(1). This includes supply fans, return/relief fans, and fan-powered terminal units associated with systems providing heating or cooling capability. Single *zone* variable-air-volume systems shall comply with the constant volume fan power limitation.

EXCEPTION:

The following fan systems are exempt from allowable fan floor horsepower requirement.

- 1. Hospital, vivarium and laboratory systems that utilize flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall be permitted to use variable volume fan power limitation.
- 2. Individual exhaust fans with motor nameplate horsepower of 1 hp or less.

C403.2.10.2 Motor nameplate horsepower. For each fan, the selected fan motor shall be no larger than the first available motor size greater than the brake horsepower (bhp). The fan brake horsepower (bhp) shall be indicated on the design documents to allow for compliance verification by the *code official*.

EXCEPTIONS:

- 1. For fans less than 6 bhp (4413 W), where the first available motor larger than the brake horsepower has a nameplate rating within 50 percent of the bhp, selection of the next larger nameplate motor size is allowed.
- 2. For fans 6 bhp (4413 W) and larger, where the first available motor larger than the bhp has a nameplate rating within 30 percent of the bhp, selection of the next larger nameplate motor size is allowed.
- 3. For fans used only in *approved* life safety applications such as smoke evacuation.
- **C403.2.10.3 Fractional hp fan motors.** Motors for fans that are 1/12 hp or greater and less than 1 hp shall be electronically commutated motors or shall have a minimum motor efficiency of 70 percent when rated in accordance with DOE 10 C.F.R. 431. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of a varying motor speed.

EXCEPTIONS:

- 1. Motors in the airstream within fan-coils and terminal units that operate only when providing heating to the space served.
- 2. Motors installed in space conditioning equipment certified under Section C403.2.3.

NEW SECTION

WAC 51-11C-403292 Table C403.2.10.1--Fan power limitation.

Table C403.2.10.1(1)

Fan Power Limitation

	Limit	Constant Volume	Variable Volume
Option 1: Fan system motor nameplate hp	Allowable nameplate motor hp	$hp \leq CFM_S \times 0.0011$	$\begin{array}{c} hp \leq \\ CFM_S \times \\ 0.0015 \end{array}$
Option 2: Fan system bhp	Allowable fan system bhp	$bhp \le CFM_S \times 0.00094 + A$	$\begin{array}{c} \text{bhp} \\ \leq \text{CFM}_S \times 0. \\ 0013 + A \end{array}$

Where:

CFM_S = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute.

hp = The maximum combined motor nameplate horsepower.

bhp = The maximum combined fan brake horsepower.

 $A = \operatorname{Sum of} [PD \times \operatorname{CFM}_D/4131]$

For SI: 1 cfm = 0.471 L/s.

Where:

PD = Each applicable pressure drop adjustment from Table C403.2.10.1(2) in. w.c.

CFM_D = The design airflow through each applicable device from Table C403.2.10.1(2) in cubic feet per minute.

For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W.

Table C403.2.10.1(2) Fan Power Limitation Pressure Drop Adjustment

Device	Adjustment				
Credits					
Fully ducted return and/or exhaust air systems	0.5 inch w.c. (2.15 inches w.c. for laboratory and vivarium systems)				
Return and/or exhaust air flow control devices	0.5 inch w.c.				
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at fan system design condition				
Particulate filtration credit: MERV 9 - 12	0.5 inch w.c.				
Particulate filtration credit: MERV 13 - 15	0.9 inch w.c.				
Particulate filtration credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at fan system design condition				
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition				
Biosafety cabinet	Pressure drop of device at fan system design condition				
Energy recovery device, other than coil runaround loop	$(2.2 \times \text{energy recovery effectiveness}) - 0.5 \text{ inch w.c.}$ for each airstream				
Coil runaround loop	0.6 inch w.c. for each airstream				
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design conditions				
Sound attenuation section	0.15 inch w.c.				
Exhaust system serving fume hoods	0.35 inch w.c.				
Laboratory and vivarium exhaust systems in high-rise buildings	0.25 inch w.c./100 feet of vertical duct exceeding 75 feet				

w.c. = water column.

For SI: 1 inch w.c.= 249 Pa, 1 inch= 25.4 mm.

- WAC 51-11C-403293 Section C403.2.11--Heating outside a building.
- **C403.2.11 Heating outside a building.** Systems installed to provide heat outside a building shall be radiant systems.

Such heating systems shall be controlled by an occupancy sensing device or a timer switch, so that the system is automatically deenergized when no occupants are present.

NEW SECTION

WAC 51-11C-403294 Section C403.2.12--System criteria.

- **C403.2.12 System criteria.** For fan and pump motors 7.5 hp and greater including motors in or serving custom and packaged air handlers serving variable air volume fan systems, constant volume fans, heating and cooling hydronic pumping systems, pool and service water pumping systems, domestic water pressure boosting systems, cooling tower fan, and other pump or fan motors where variable flows are required, there shall be:
 - 1. Variable speed drives; or
- 2. Other controls and devices that will result in fan and pump motor demand of no more than 30 percent of design wattage at 50 percent of design air volume for fans when static pressure set point equals 1/3 the total design static pressure, and 50 percent of design water flow for pumps, based on manufacturer's certified test data. Variable inlet vanes, throttling valves (dampers), scroll dampers or bypass circuits shall not be allowed.

EXCEPTION:

Variable speed devices are not required for motors that serve:

- $1. \ Fans \ or pumps \ in \ packaged \ equipment \ where \ variable \ speed \ drives \ are \ not \ available \ as \ a \ factory \ option \ from \ the \ equipment \ manufacturer.$
- 2. Fans or pumps that are required to operate only for emergency fire-life-safety events (e.g., stairwell pressurization fans, elevator pressurization fans, fire pumps, etc.).
- **C403.2.12.1 Heat rejection equipment.** The requirements of this section apply to heat rejection equipment used in comfort cooling systems such as air-cooled condensers, open cooling towers, closed-circuit cooling towers, and evaporative condensers.

EXCEPTION: Heat rejection devices included as an integral part of equipment listed in Tables C403.2.3(1) through C403.2.3(3).

Heat rejection equipment shall have a minimum efficiency performance not less than values specified in Table C403.2.3(8). These requirements apply to all propeller, axial fan and centrifugal fan cooling towers. Table C403.2.3(8) specifies requirements for air-cooled condensers that are within rating conditions specified within the table.

C403.2.12.1.1 Variable flow controls. Cooling tower fans 7.5 hp and greater shall have control devices that vary flow by

controlling the leaving fluid temperature or condenser temperature/pressure of the heat rejection device.

C403.2.12.1.2 Limitation on centrifugal fan cooling towers. Open cooling towers with a combined rated capacity of 1,100 gpm and greater at 95°F condenser water return, 85°F condenser water supply and 75°F outdoor wet-bulb temperature shall meet the energy efficiency requirement for axial fan open circuit cooling towers.

EXCEPTION:

Open circuit cooling towers that are ducted (inlet or discharge) or have external sound attenuation that requires external static pressure capability.

C403.2.12.2 Large volume fan systems. Single or multiple fan systems serving a zone or adjacent zones without separating walls with total air flow over 10,000 cfm (3,540 L/s) are required to reduce airflow based on space thermostat heating and cooling demand. A variable speed drive shall reduce airflow to a maximum 75 percent of peak airflow or minimum ventilation air requirement as required by Section 403 of the *International Mechanical Code*, whichever is greater.

EXCEPTIONS:

- 1. Systems where the function of the supply air is for purposes other than temperature control, such as maintaining specific humidity levels or supplying an exhaust system.
- 2. Dedicated outdoor air supply unit(s) with heat recovery where airflow is equal to the minimum ventilation requirements and other fans cycle off unless heating or cooling is required.
- 3. An area served by multiple units where designated ventilation units have 50 percent or less of total area airflow and nonventilation unit fans cycle off when heating or cooling is not required.

All air-conditioning equipment and air-handling units with direct expansion cooling and a cooling capacity at AHRI conditions greater than or equal to 110,000 Btu/h that serve single zones shall have their supply fans controlled by two-speed motors or variable speed drives. At cooling demands less than or equal to 50 percent, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:

- 1. Two-thirds of the full fan speed; or
- 2. The volume of outdoor air required to meet the ventilation requirements of Section 403 of the *International Mechanical Code*.

NEW SECTION

WAC 51-11C-403295 Section C403.2.13--Electric motor efficiency.

C403.2.13 Electric motor efficiency. Design A and B squirrel-cage, T-frame induction permanently wired polyphase motors of 1 hp or more having synchronous speeds of 3,600, 1,800 and 1,200 rpm shall have a nominal full-load motor efficiency no less than the corresponding values for energy efficient motors provided in NEMA Standard MG-1.

EXCEPTIONS:

- 1. Motors used in systems designed to use more than one speed of a multi-speed motor.
- 2. Motors used as a component of the equipment meeting the minimum equipment efficiency requirements of Section C403.2.3 and Tables C403.2.3(1) through C403.2.3(9) provided that the motor input is included when determining the equipment efficiency.

- 3. Motors that are an integral part of specialized process equipment.
- 4. Where the motor is integral to a listed piece of equipment for which no complying motor has been approved.

Fan motors less than 1 hp in series terminal units shall be electronically commutated motors, or shall have a minimum motor efficiency of 65 percent when rated in accordance with NEMA Standard MG-1 at full load rating conditions.

NEW SECTION

WAC 51-11C-40330 Section C403.3--Simple HVAC systems and equipment.

C403.3 Simple HVAC systems and equipment (Prescriptive). This section applies to unitary or packaged HVAC systems listed in Tables C403.2.3(1) through C403.2.3(8), each serving one zone and controlled by a single thermostat in the zone served. It also applies to two-pipe heating systems serving one or more zones, where no cooling system is installed.

To qualify as a simple system, systems shall have no active humidification or simultaneous heating and cooling and shall be one of the following:

- 1. Air cooled, constant volume packaged equipment, which provide heating, cooling or both, and require only external connection to duct work and energy services with cooling capacity of 135,000 Btu/h or less.
- 2. Air cooled, constant volume split systems, which provide heating, cooling or both, with cooling capacity of $84,000 \, \text{Btu/h}$ or less.
- 3. Heating only systems which have a capacity of less than 1,000 cfm or which have a minimum outside air supply of less than 30 percent of the total air circulation.

The combined airflow rate of all simple systems serving single rooms must be less than $10,000~\rm cfm$ or they do not qualify as simple systems.

NEW SECTION

WAC 51-11C-40331 Section C403.3.1--Economizers.

C403.3.1 Economizers. Each cooling system that has a fan shall include an air economizer meeting the requirements of Sections C403.3.1.1 through C403.3.1.1.4.

EXCEPTION:

Economizers are not required for the systems listed below:

1. Qualifying small equipment: This exception shall not be used for unitary cooling equipment installed outdoors or in a mechanical room adjacent to the outdoors. This exception is allowed to be used for other cooling units and split systems with a total cooling capacity rated in accordance with Section C403.2.3 of less than 33,000 Btu/h

(hereafter referred to as qualifying small systems) provided that these are high-efficiency cooling equipment with SEER and EER values more than 15 percent higher than minimum efficiencies listed in Tables C403.2.3 (1) through (3), in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify for this exception. The total capacity of all qualifying small equipment without economizers shall not exceed 72,000 Btu/h per building, or 5 percent of its air economizer capacity, whichever is greater. That portion of the equipment serving residential occupancies is not included in determining the total capacity of all units without economizers in a building. Redundant units are not counted in the capacity limitations. This exception shall not be used for the shell-and-core permit or for the initial tenant improvement or for Total Building Performance.

- 2. Systems with dehumidification that affect other systems so as to increase the overall building energy consumption. New humidification equipment shall comply with Section C403.2.3.4.
- 3. For residential occupancies, cooling units installed outdoors or in a mechanical room adjacent to outdoors with a total cooling capacity less than 20,000 Btu/h and other cooling units with a total cooling capacity less than 54,000 Btu/h provided that these are high-efficiency cooling equipment with IEER, SEER, and EER values more than 15 percent higher than minimum efficiencies listed in Tables C403.2.3 (1) through (10), in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify for this exception. For split systems and VRF systems, compliance is based on the cooling capacity of individual fan coil units.
- 4. Where the cooling *efficiency* meets or exceeds the *efficiency* requirements in Table C403.3.1(2).

Table C403.3.1(2)
Equipment Efficiency Performance
Exception for Economizers

Climate Zones	Cooling Equipment Performance Improvement (EER OR IPLV)
2B	10% Efficiency Improvement
3B	15% Efficiency Improvement
4B	20% Efficiency Improvement

- **C403.3.1.1 Air economizers.** Air economizers shall comply with Sections C403.3.1.1.1 through C403.3.1.1.4.
- **C403.3.1.1.1 Design capacity.** Air economizer systems shall be capable of modulating *outdoor air* and return air dampers to provide up to 100 percent of the design supply air quantity as *outdoor air* for cooling.
- **C403.3.1.1.2 Control signal.** Economizer dampers shall be capable of being sequenced with the mechanical cooling equipment and shall not be controlled by only mixed air temperature. Air economizers on systems with cooling capacity greater than 65,000 Btu/h shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

EXCEPTION:

The use of mixed air temperature limit control shall be permitted for systems that are both controlled from space temperature (such as single *zone* systems) and having cooling capacity less than 65,000 Btu/h.

- **C403.3.1.1.3 High-limit shutoff.** Air economizers shall be capable of automatically reducing *outdoor air* intake to the design minimum *outdoor air* quantity when *outdoor air* intake will no longer reduce cooling energy usage. High-limit shutoff control types for specific climates shall be chosen from Table C403.3.1.1.3(1). High-limit shutoff control settings for these control types shall be those specified in Table C403.3.1.1.3(2).
- **C403.3.1.1.4 Relief of excess outdoor air.** Systems shall be capable of relieving excess *outdoor air* during air economizer operation to prevent over-pressurizing the building. The relief air outlet shall be located to avoid recirculation into the

building.

NEW SECTION

WAC 51-11C-40332 Section C403.3.2--Hydronic system controls.

C403.3.2 Hydronic system controls. Hydronic systems of at least 300,000 Btu/h (87,930 W) design output capacity supplying heated and chilled water to comfort conditioning systems shall include controls that meet the requirements of Section C403.4.3.

NEW SECTION

WAC 51-11C-40340 Section C403.4--Complex HVAC systems and equipment.

C403.4 Complex HVAC systems and equipment (prescriptive). This section applies to HVAC equipment and systems not covered in Section C403.3.

For buildings with a total equipment cooling capacity of 300 tons and above, the equipment shall comply with one of the following:

- 1. No one unit shall have a cooling capacity of more than 2/3 of the total installed cooling equipment capacity;
 - 2. The equipment shall have a variable speed drive; or
 - 3. The equipment shall have multiple compressors.

NEW SECTION

WAC 51-11C-40341 Section C403.4.1--Economizers.

C403.4.1 Economizers. Air economizers shall be provided on all new systems including those serving computer server rooms, electronic equipment, radio equipment, and telephone switchgear. Economizers shall comply with Sections C403.4.1.1 through C403.4.1.4.

EXCEPTIONS:

- 1. Water-cooled refrigeration equipment serving chilled beams and chilled ceiling space cooling systems only which are provided with a water economizer meeting the requirements of Section C403.4.1. Water economizer capacity per building shall not exceed 500 tons. This exception shall not be used for Total Building Performance. 2. Systems complying with all of the following criteria:
- 2.1. Consist of multiple water source heat pumps connected to a common water loop;
- 2.2. Have a minimum of 60 percent air economizer;
- 2.3. Have water source heat pumps with an EER at least 15 percent higher for cooling and a COP at least 15 percent

higher for heating than that specified in Section C403.2.3;

- 2.4. Where provided, have a central boiler or furnace efficiency of 90 percent minimum for units up to 199,000 Btu/h; and
- 2.5. Provide heat recovery with a minimum 50 percent heat recovery effectiveness as defined in Section C403.2.6 to preheat the outside air supply.
- 3. Chilled water terminal units connected to systems with chilled water generation equipment with IPLV values more than 25 percent higher than minimum part load efficiencies listed in Table C403.2.3(7), in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify for this exception. The total capacity of all systems without economizers shall not exceed 480,000 Btu/h per building, or 20 percent of its air economizer capacity, whichever is greater. That portion of the equipment serving Group R Occupancy is not included in determining the total capacity of all units without economizers in a building. This exception shall not be used for the initial permit (this includes any initial permit for the space including, but not limited to, the shell-and-core permit, built-to-suit permit, and tenant improvement permit) or for Total Building Performance Method.
- 4. For Group R occupancies, cooling units installed outdoors or in a mechanical room adjacent to outdoors with a total cooling capacity less than 20,000 Btu/h and other cooling units with a total cooling capacity less than 54,000 Btu/h provided that these are high-efficiency cooling equipment with SEER and EER values more than 15 percent higher than minimum efficiencies listed in Tables C403.2.3 (1) through (3), in the appropriate size category, using the same test procedures. Equipment shall be listed in the appropriate certification program to qualify for this exception. For split systems, compliance is based on the cooling capacity of individual fan coil units.
- 5. Equipment used to cool any dedicated server room, electronic equipment room or telecom switch room provided that they completely comply with Option a, b, or c in the table below. The total capacity of all systems without economizers shall not exceed 240,000 Btu/h per building or 10 percent of its air economizer capacity, whichever is greater. This exception shall not be used for Total Building Performance.

	Equipment Type	Higher Equipment Efficiency	Part-Load Control	Economizer
Option a	Tables C403.2.3(1) and C403.2.3(2) ^a	+15% ^b	Required over 85,000 Btu/h ^c	None Required
Option b	Tables C403.2.3(1) and C403.2.3(2) ^a	+5% ^d	Required over 85,000 Btu/h ^c	Waterside Economizer
Option c	ASHRAE Standard 127 ^f	+0% ^g	Required over 85,000 Btu/h ^c	Waterside Economizer

Notes for Exception 5:

^aFor a system where all of the cooling equipment is subject to the AHRI standards listed in Tables C403.2.3(1) and C403.2.3(2), the system shall comply with all of the following (note that if the system contains any cooling equipment that exceeds the capacity limits in Table C403.2.3(1) or C403.2.3(2), or if the system contains any cooling equipment that is not included in Table C403.2.3(1) or C403.2.3(2), then the system is not allowed to use this option).

^bThe cooling equipment shall have an EER value and an IPLV value that is a minimum of 15 percent greater than the value listed in Tables C403.2.3(1) and C403.2.3(2) (1.15 x values in Tables C403.2.3(1) and C403.2.3(2)).

^cFor units with a total cooling capacity over 85,000 Btu/h, the system shall utilize part-load capacity control schemes that are able to modulate to a part-load capacity of 50 percent of the load or less that results in the compressor operating at the same or higher EER at part loads than at full load (e.g., minimum of two-stages of compressor unloading such as cylinder unloading, two-stage scrolls, dual tandem scrolls, but hot gas bypass is not credited as a compressor unloading system).

^dThe cooling equipment shall have an EER value and an IPLV value that is a minimum of 5 percent greater than the value listed in Tables C403.2.3(1) and C403.2.3(2) (1.05 x values in Tables C403.2.3(1) and C403.2.3(2)).

eThe system shall include a water economizer in lieu of air economizer. Water economizers shall be capable of providing the total concurrent cooling load served by the connected terminal equipment lacking airside economizer, at outside air temperatures of 50°F dry-bulb/45°F wet-bulb and below. For this calculation, all factors including solar and internal load shall be the same as those used for peak load calculations, except for the outside temperatures. The equipment shall be served by a dedicated condenser water system unless a nondedicated condenser water system exists that can provide appropriate water temperatures during hours when waterside economizer cooling is available.

^fFor a system where all cooling equipment is subject to ASHRAE Standard 127.

^gThe cooling equipment subject to the ASHRAE Standard 127 shall have an EER value and an IPLV value that is equal or greater than the value listed in Tables C403.2.3(1) and C403.2.3(2) when determined in accordance with the rating conditions ASHRAE Standard 127 (i.e., not the rating conditions in AHRI Standard 210/240 or 340/360). This information shall be provided by an independent third party.

6. Variable refrigerant flow (VRF) systems, multiple-zone split-system heat pumps, consisting of multiple, individually metered indoor units with multi-speed fan motors, served on a single common refrigeration circuit with an exterior reverse-cycle heat pump with variable speed compressor(s) and variable speed condenser fan(s). These systems shall also be capable of providing simultaneous heating and cooling operation, where recovered energy from the indoor units operating in one mode can be transferred to one or more indoor units operating in the other mode, and shall serve at least 20 percent internal (no perimeter wall within 12') and 20 percent perimeter zones (as determined by conditioned floor area) and the outdoor unit shall be at least 65,000 Btu/h in total capacity. Systems utilizing this exception shall have 50 percent heat recovery effectiveness as defined by Section C403.2.6 on the outside air. For the purposes of this exception, dedicated server rooms, electronic equipment rooms or telecom switch rooms are not considered perimeter zones. This exception shall be limited to buildings of 60,000 square feet and less.

C403.4.1.1 Design capacity. Water economizer systems shall be

capable of cooling supply air by indirect evaporation and providing up to 100 percent of the expected system cooling load at outdoor air temperatures of 50°F dry-bulb (10°C dry-bulb)/45°F wet-bulb (7.2°C wet-bulb) and below.

EXCEPTION:

Systems in which a water economizer is used and where dehumidification requirements cannot be met using outdoor air temperatures of 50° F dry-bulb (10° C dry-bulb)/ 45° F wet-bulb (7.2° C wet-bulb) shall satisfy 100 percent of the expected system cooling load at 45° F dry-bulb (7.2° C dry-bulb)/ 40° F wet-bulb (4.5° C wet-bulb).

- **C403.4.1.2 Maximum pressure drop.** Precooling coils and water-to-water heat exchangers used as part of a water economizer system shall either have a waterside pressure drop of less than 15 feet (4572 mm) of water or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the system is in the normal cooling (noneconomizer) mode.
- **C403.4.1.3 Integrated economizer control.** Economizer systems shall be integrated with the mechanical cooling system and be capable of providing partial cooling even where additional mechanical cooling is required to meet the remainder of the cooling load.

EXCEPTIONS:

- 1. Direct expansion systems that include controls that reduce the quantity of *outdoor air* required to prevent coil frosting at the lowest step of compressor unloading, provided this lowest step is no greater than 25 percent of the total system capacity.
- 2. Individual direct expansion units that have a rated cooling capacity less than 54,000 Btu/h (15,827 W) and use nonintegrated economizer controls that preclude simultaneous operation of the economizer and mechanical cooling.
- **C403.4.1.4 Economizer heating system impact.** HVAC system design and economizer controls shall be such that economizer operation does not increase the building heating energy use during normal operation.

EXCEPTION:

Economizers on VAV systems that cause zone level heating to increase due to a reduction in supply air temperature.

NEW SECTION

WAC 51-11C-40342 Section C403.4.2--VAV fan control.

- **C403.4.2 Variable air volume (VAV) fan control.** Individual VAV fans with motors of 7.5 horsepower (5.6 kW) or greater shall be:
 - 1. Driven by a mechanical or electrical variable speed drive;
 - 2. Driven by a vane-axial fan with variable-pitch blades; or
- 3. The fan shall have controls or devices that will result in fan motor demand of no more than 30 percent of their design wattage at 50 percent of design airflow when static pressure set point equals one-third of the total design static pressure, based on manufacturer's certified fan data.
- **C403.4.2.1 Static pressure sensor location.** Static pressure sensors used to control VAV fans shall be placed in a position such that the controller setpoint is no greater than one-third the total design fan static pressure, except for systems with *zone* reset

control complying with Section C403.4.2.2. For sensors installed downstream of major duct splits, at least one sensor shall be located on each major branch to ensure that static pressure can be maintained in each branch.

C403.4.2.2 Set points for direct digital control. For systems with direct digital control of individual *zone* boxes reporting to the central control panel, the static pressure setpoint shall be reset based on the *zone* requiring the most pressure, i.e., the setpoint is reset lower until one *zone* damper is nearly wide open.

NEW SECTION

WAC 51-11C-40343 Section C403.4.3--Hydronic systems controls.

- C403.4.3 Hydronic systems controls. The heating of fluids that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Sections C403.4.3.1 through C403.4.3.3. Hydronic heating systems comprised of multiple-packaged boilers and designed to deliver conditioned water or steam into a common distribution system shall include automatic controls capable of sequencing operation of the boilers. Hydronic heating systems comprised of a single boiler and greater than 500,000 Btu/h (146,550 W) input design capacity shall include either a multi-staged or modulating burner.
- C403.4.3.1 Three-pipe system. Hydronic systems that use a common return system for both hot water and chilled water are prohibited.
- **C403.4.3.2 Two-pipe changeover system.** Systems that use a common distribution system to supply both heated and chilled water shall be designed to allow a dead band between changeover from one mode to the other of at least 15°F (8.3°C) outside air temperatures; be designed to and provided with controls that will allow operation in one mode for at least 4 hours before changing over to the other mode; and be provided with controls that allow heating and cooling supply temperatures at the changeover point to be no more than 30°F (16.7°C) apart.
- **C403.4.3.3 Hydronic (water loop) heat pump systems.** Hydronic heat pump systems shall comply with Sections C403.4.3.3.1 through C403.4.3.3.3.
- **C403.4.3.3.1 Temperature dead band.** Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are capable of providing a heat pump water supply temperature dead band of at least 20°F (11.1°C) between initiation of heat rejection and heat addition by the central devices.

EXCEPTION:

Where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on real time conditions of demand and capacity, dead bands of less than $20^{\circ}F$ ($11^{\circ}C$) shall be permitted.

C403.4.3.3.2 Heat rejection. Heat rejection equipment shall comply with Sections C403.4.3.3.2.1 and C403.4.3.3.2.2.

EXCEPTION: Where it can be demonstrated that a heat pump system will be required to reject heat throughout the year.

- C403.4.3.3.2.1 Climate Zones 3 and 4. For Climate Zones 3 and 4:

 1. If a closed-circuit cooling tower is used directly in the heat pump loop, either an automatic valve shall be installed to
- heat pump loop, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower, or lower leakage positive closure dampers shall be provided.
- 2. If an open-circuit tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower.
- 3. If an open- or closed-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the cooling tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.
- **C403.4.3.3.2.2 Climate Zones 5 through 8.** For Climate Zones 5 through 8, if an open- or closed-circuit cooling tower is used, then a separate heat exchanger shall be provided to isolate the cooling tower from the heat pump loop, and heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop and providing an automatic valve to stop the flow of fluid.
- C403.4.3.3 Isolation valve. Each hydronic heat pump on the hydronic system having a total pump system power exceeding 10 horsepower (hp) (7.5 kW) shall have a two-way (but not three-way) valve. For the purposes of this section, pump system power is the sum of the nominal power demand (i.e., nameplate horsepower at nominal motor efficiency) of motors of all pumps that are required to operate at design conditions to supply fluid from the heating or cooling source to all heat transfer devices (e.g., coils, heat exchanger) and return it to the source. This converts the system into a variable flow system and, as such, the primary circulation pumps shall comply with the variable flow requirements in Section C403.4.3.6.
- **C403.4.3.4 Part load controls.** Hydronic systems greater than or equal to 300,000 Btu/h (87,930 W) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that have the capability to:
- 1. Automatically reset the supply-water temperatures using zone-return water temperature, building-return water temperature, or outside air temperature as an indicator of building heating or cooling demand. The temperature shall be capable of being reset by at least 25 percent of the design supply-to-return water temperature difference; and
- 2. Reduce system pump flow by at least 50 percent of design flow rate utilizing adjustable speed drive(s) on pump(s), or multiple-staged pumps where at least one-half of the total pump

horsepower is capable of being automatically turned off or control valves designed to modulate or step down, and close, as a function of load, or other *approved* means.

Hydronic systems serving hydronic heat pumps are exempt from item 1, and only those hydronic systems with a total pump system power greater than 3 hp (2.2 kw) shall have controls meeting the requirements of item 2, above.

C403.4.3.5 Pump isolation. Chilled water plants including more than one chiller shall have the capability to reduce flow automatically through the chiller plant when a chiller is shut down and automatically shut off flow to chillers that are shut down. Chillers piped in series for the purpose of increased temperature differential shall be considered as one chiller.

EXCEPTION: Chillers that are piped in series for the purpose of increased temperature differential.

Boiler plants including more than one boiler shall have the capability to reduce flow automatically through the boiler plant when a boiler is shut down and automatically shut off flow to chillers that are shut down.

- **C403.4.3.6 Variable flow controls.** Individual pumps requiring variable speed control per Section C403.4.9 shall be controlled in one of the following manners:
- 1. For systems having a combined pump motor horsepower less than or equal to 20 hp (15 kW) and without direct digital control of individual coils, pump speed shall be a function of either:
 - 1.1. Required differential pressure; or
- 1.2. Reset directly based on zone hydronic demand, or other zone load indicators; or
- 1.3. Reset directly based on pump power and pump differential pressure.
- 2. For systems having a combined pump motor horsepower that exceeds 20 hp (15 kW) or smaller systems with direct digital control, pump speed shall be a function of either:
- 2.1. The static pressure set point as reset based on the valve requiring the most pressure; or
 - 2.2. Directly controlled based on zone hydronic demand.

NEW SECTION

WAC 51-11C-403431 Table C403.4.3.1.1.3--High limit shutoff controls.

Table C403.3.1.1.3(1)

High-limit Shutoff Control Options for Air Economizers

Climate Zones	Allowed Control Types	Prohibited Control Types
1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	Fixed dry-bulb Differential dry-bulb Electronic enthalpy ^a Differential enthalpy Dew-point and dry-bulb temperatures	Fixed enthalpy
1A, 2A, 3A, 4A	Fixed dry-bulb Fixed enthalpy Electronic enthalpy ^a Differential enthalpy Dew-point and dry-bulb temperatures	Differential dry-bulb
All other climates	Fixed dry-bulb Differential dry-bulb Fixed enthalpy Electronic enthalpy ^a Differential enthalpy Dew-point and dry-bulb temperatures	

^aElectronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm.

Table C403.3.1.1.3(2)
High-limit Shutoff Control Setting for Air Economizers

		Required High Limit (Economizer off When):			
Device Type	Climate Zone	Equation	Description		
Fixed dry-bulb	1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	$T_{OA} > 75^{\circ}$ F	Outdoor air temperature exceeds 75°F		
	5A, 6A, 7A	$T_{OA} > 70^{\circ} \text{F}$	Outdoor air temperature exceeds 70°F		
	All other zones	$T_{OA} > 65^{\circ}$ F	Outdoor air temperature exceeds 65°F		
Differential dry-bulb	1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature		
Fixed enthalpy	All	$h_{OA} > 28 \text{ Btu/lb}^{\text{a}}$	Outdoor air enthalpy exceeds 28 Btu/lb of dry air ^a		
Electronic enthalpy	All	$(T_{OA}, RH_{OA}) > A$	Outdoor air temperature/RH exceeds the "A" setpoint curve ^b		
Differential enthalpy	All	$h_{OA} > H_{ra}$	Outdoor air enthalpy exceeds return air enthalpy		
Dew-point and dry-bulb temperatures	All	$DP_{OA} > 55$ °F or $T_{OA} > 75$ °F	Outdoor air dry-bulb exceeds 75°F or outside dew-point exceeds 55°F (65 gr/lb)		

For SI: $^{\circ}$ C = ($^{\circ}$ F - 32) × 5/9, 1 Btu/lb = 2.33 kJ/kg.

NEW SECTION

WAC 51-11C-40344 Section C403.4.4--Heat rejection equipment fan speed control.

C403.4.4 Heat rejection equipment fan speed control. Each fan

^a At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F and 50 percent relative humidity. As an example, at approximately 6,000 feet elevation the fixed enthalpy limit is approximately 30.7 Btu/lb.

^b Setpoint "A" corresponds to a curve on the psychometric chart that goes through a point at approximately 75°F and 40 percent relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

powered by a motor of 7.5~hp (5.6~kW) or larger shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

NEW SECTION

- WAC 51-11C-40345 Section C403.4.5--Requirements for complex mechanical systems serving multiple zones.
- C403.4.5 Requirements for complex mechanical systems serving multiple zones. Sections C403.4.5.1 through C403.4.5.4 shall apply to complex mechanical systems serving multiple zones. Supply air systems serving multiple zones shall be VAV systems which, during periods of occupancy, are designed and capable of being controlled to reduce primary air supply to each zone to one of the following before reheating, recooling or mixing takes place:
 - 1. Thirty percent of the maximum supply air to each zone.
- 2. Three hundred cfm (142 L/s) or less where the maximum flow rate is less than 10 percent of the total fan system supply airflow rate.
- 3. The minimum ventilation requirements of Chapter 4 of the International Mechanical Code.
- 4. Minimum flow rates required by applicable codes or standards for occupant health and safety.

EXCEPTION:

The following define where individual *zones* or where entire air distribution systems are exempted from the requirement for VAV control:

- 1. Reserved.
- 2. *Zones* or supply air systems where at least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
- $3.\ Zones$ where special humidity levels are required to satisfy process needs.
- 4. Zones with a peak supply air quantity of 300 cfm (142 L/s) or less and where the flow rate is less than 10 percent of the total fan system supply airflow rate.
- 5. *Zones* where the volume of air to be reheated, recooled or mixed is no greater than the volume of outside air required to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.
- 6. *Zones* or supply air systems with thermostatic and humidistatic controls capable of operating in sequence the supply of heating and cooling energy to the *zones* and which are capable of preventing reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.
- **C403.4.5.1** Single duct variable air volume (VAV) systems, terminal devices. Single duct VAV systems shall use terminal devices capable of reducing the supply of primary supply air before reheating or recooling takes place.
- **C403.4.5.2 Dual duct and mixing VAV systems, terminal devices.** Systems that have one warm air duct and one cool air duct shall use terminal devices which are capable of reducing the flow from one duct to a minimum before mixing of air from the other duct takes place.
- C403.4.5.3 Reserved.
- C403.4.5.4 Supply-air temperature reset controls. Multiple zone

HVAC systems shall include controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls shall be capable of resetting the supply air temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

EXCEPTIONS:

- 1. Systems that prevent reheating, recooling or mixing of heated and cooled supply air.
- 2. Seventy-five percent of the energy for reheating is from site-recovered or site solar energy sources.
- 3. Zones with peak supply air quantities of 300 cfm (142 L/s) or less.

NEW SECTION

WAC 51-11C-40346 Section C403.4.6--Heat recovery for service water heating.

C403.4.6 Heat recovery for service water heating. Condenser heat recovery shall be installed for heating or reheating of service hot water provided the facility operates 24 hours a day, the total installed heat capacity of water cooled systems exceeds 1,500,000 Btu/hr of heat rejection, and the design service water heating load exceeds 250,000 Btu/hr.

The required heat recovery system shall have the capacity to provide the smaller of:

- 1. Sixty percent of the peak heat rejection load at design conditions; or
- 2. The preheating required to raise the peak service hot water draw to $85^{\circ}F$ (29°C).

EXCEPTIONS:

- 1. Facilities that employ condenser heat recovery for space heating or reheat purposes with a heat recovery design exceeding 30 percent of the peak water-cooled condenser load at design conditions.
- 2. Facilities that provide 60 percent of their service water heating from site solar or site recovered energy or from other sources.

NEW SECTION

WAC 51-11C-40347 Section C403.4.7--Hot gas bypass limitation.

C403.4.7 Hot gas bypass limitation. Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table C403.4.7.

EXCEPTION:

Unitary packaged systems with cooling capacities not greater than 90,000 Btu/h (26,379 W).

Table C403.4.7

Maximum Hot Gas Bypass Capacity

Rated Capacity	Maximum Hot Gas Bypass Capacity (% of total capacity)
≤ 240,000 Btu/h	50
> 240,000 Btu/h	25

For SI: 1 British thermal unit per hour = 0.2931 W.

NEW SECTION

WAC 51-11C-40350 Section C403.5--Walk-in coolers and freezers.

C403.5 Walk-in coolers and walk-in freezers. Walk-in coolers and walk-in freezers shall comply with all of the following:

- 1. Anti-sweat heaters without anti-sweat heater controls shall have a total door rail, glass, and frame heater power draw of less than or equal to 7.1 watts per square foot of door opening for $walk-in\ freezers$, and 3.0 watts per square foot of door opening for $walk-in\ coolers$.
- 2. Anti-sweat heater controls shall reduce the energy use of the anti-sweat heater as a function of the relative humidity in the air outside the door or to the condensation on the inner glass pane.
- 3. Evaporator fan motors that are less than 1 horsepower and less than 460 volts shall use electronically commutated motors (brushless direct current motors) or 3-phase motors.
- 4. Condenser fan motors that are less than 1 horsepower shall use electronically commutated motors, permanent split capacitortype motors or 3-phase motors.

NEW SECTION

WAC 51-11C-40360 Section C403.6--Refrigerated warehouse coolers and freezers.

C403.6 Refrigerated warehouse coolers and refrigerated warehouse freezers. Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with all of the following:

1. Evaporator fan motors that are less than 1 horsepower and less than 460 volts shall use electronically commutated motors

(brushless direct current motors) or 3-phase motors.

2. Condenser fan motors that are less than 1 horsepower shall use electronically commutated motors, permanent split capacitortype motors or 3-phase motors.

NEW SECTION

WAC 51-11C-40400 Section C404--Service water heating (Mandatory).

NEW SECTION

WAC 51-11C-40401 Section C404.1--General.

C404.1 General. This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

NEW SECTION

WAC 51-11C-40402 Section C404.2--Service water-heating equipment performance efficiency.

C404.2 Service water-heating equipment performance efficiency. Water-heating equipment and hot water storage tanks shall meet the requirements of Table C404.2. The efficiency shall be verified through certification and *listed* under an *approved* certification program, or if no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the manufacturer.

NEW SECTION

WAC 51-11C-404021 Table C404.2--Minimum performance of waterheating equipment.

Table C404.2

Minimum Performance of Water-Heating Equipment

Equipment Type	Size Category (input)	Subcategory or Rating Condition	Performance Required ^{a, b}	Test Procedure
	$\leq 12 \text{ kW}$	Resistance	0.97 - 0.00 132V, EF	DOE 10 C.F.R. Part 430
Water heaters, electric	> 12 kW	Resistance	1.73V + 155 SL, Btu/h	ANSI Z21.10.3
	≤ 24 amps and ≤ 250 volts	Heat pump	0.93 - 0.00 132 <i>V</i> , EF	DOE 10 C.F.R. Part 430
	≤ 75,000 Btu/h	≥ 20 gal	0.67 - 0.0019V, EF	DOE 10 C.F.R. Part 430
Storage water heaters, gas	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t (Q/800 + 110√ V) SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	80% $E_{\rm t}$ (Q/800 + 110√ V) SL, Btu/h	
	> 50,000 Btu/h and < 200,000 Btu/h	≥ 4,000 (Btu/h)/gal and < 2 gal	0.62 - 0.00 19 <i>V</i> , EF	DOE 10 C.F.R. Part 430
Instantaneous water heaters, gas	≥ 200,000 Btu/h ^c	≥ 4,000 Btu/h/gal and < 10 gal	80% E,	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E _t (Q/800 + 110√V) SL, Btu/h	
Storage water heaters, oil	≤ 105,000 Btu/h	≥ 20 gal	0.59 - 0.0019V, EF	DOE 10 C.F.R. Part 430
	> 105,000 Btu/h	< 4,000 Btu/h/gal	$78\% E_{t}$ (Q/800 + 110√V) SL, Btu/h	ANSI Z21.10.3
	≤ 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 2 gal	0.59 - 0.0019V, EF	DOE 10 C.F.R. Part 430
Instantaneous water heaters, oil	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E _t	ANSI Z21.10.3
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	$78\% E_t$ (Q/800 + 110√V) SL, Btu/h	
Hot water supply boilers, gas and oil	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E,	ANSI Z21.10.3
Hot water supply boilers, gas	≥ 300,000 Btu/h and < 12,500,000 Btu/h	\geq 4,000 Btu/h/gal and \geq 10 gal	80% E_t (Q/800 + 110 \sqrt{V}) SL, Btu/h	
Hot water supply boilers, oil	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and > 10 gal	$78\% E_{t}$ (Q/800 + 110√V) SL, Btu/h	
Pool heaters, gas and oil	All		78% E _t	ASHRAE 146
Heat pump pool heaters	All		4.0 COP	AHRI 1160
Unfired storage tanks	All		Minimum insulation requirement R-12.5 (h ● ft² ● °F)/Btu	(none)

For SI: $^{\circ}$ C = [($^{\circ}$ F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.

NEW SECTION

WAC 51-11C-40403 Section C404.3--Temperature controls.

C404.3 Temperature controls. Service water-heating equipment shall

^aEnergy factor (EF) and thermal efficiency (E_t) are minimum requirements. In the EF equation, V is the rated volume in gallons

bStandby loss (SL) is the maximum Btu/h based on a nominal 70°F temperature difference between stored water and ambient requirements. In the SL equation, Q is the nameplate input rate in Btu/h. In the SL equation for electric water heaters, V is the rated volume in gallons. In the SL equation for oil and gas water heaters and boilers, V is the rated volume in gallons. Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

be provided with controls to allow a setpoint of $110^{\circ}F$ (43°C) for equipment serving dwelling units and $90^{\circ}F$ (32°C) for equipment serving other occupancies. The outlet temperature of lavatories in public facility rest rooms shall be limited to $110^{\circ}F$ (43°C).

NEW SECTION

WAC 51-11C-40404 Section C404.4--Heat traps.

C404.4 Heat traps. Water-heating equipment not supplied with integral heat traps and serving noncirculating systems shall be provided with heat traps on the supply and discharge piping associated with the equipment.

NEW SECTION

WAC 51-11C-40405 Section C404.5--Water heater installation.

C404.5 Water heater installation. Electric water heaters in unconditioned spaces or on concrete floors shall be placed on an incompressible, insulated surface with a minimum thermal resistance of R-10.

NEW SECTION

WAC 51-11C-40406 Section C404.6--Pipe insulation.

C404.6 Pipe insulation. For automatic-circulating hot water and heat-traced systems, piping shall be insulated with not less than 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h × ft² × °F (1.53 W per 25 mm/m² × K). The first 8 feet (2438 mm) of piping in nonhot-water-supply temperature maintenance systems served by equipment without integral heat traps shall be insulated with 0.5 inch (12.7 mm) of material having a conductivity not exceeding 0.27 Btu per inch/h × ft² × °F (1.53 W per 25 mm/m² × K).

EXCEPTIONS:

1. Heat-traced piping systems shall meet the insulation thickness requirements per the manufacturer's installation instructions. Untraced piping within a heat traced system shall be insulated with not less than 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h \times ft² \times °F (1.53 W per 25 mm/m² \times K).

2. Hot water piping that is part of the final pipe run to the plumbing fixture and is not part of the automatic-circulating hot water recirculation path is not required to meet the minimum insulation requirements of C404.6.

WAC 51-11C-40407 Section C404.7--Hot water system controls.

C404.7 Hot water system controls. Circulating hot water system pumps or heat trace shall be arranged to be turned off either automatically or manually when there is limited hot water demand. Ready access shall be provided to the operating controls.

NEW SECTION

WAC 51-11C-40408 Section C404.8--Shut-off controls.

C404.8 Shut-off controls. Systems designed to maintain usage temperatures in hot water pipes, such as circulating hot water systems or heat traced pipes, shall be equipped with automatic time switches or other controls to turn off the system during periods of nonuse.

NEW SECTION

WAC 51-11C-40409 Section C404.9--Domestic hot water meters.

C404.9 Domestic hot water meters. Each individual dwelling unit in a Group R-2 multi-family residential occupancy with central service shall be provided with a domestic hot water meter to allow for domestic hot water billing based on actual domestic hot water usage.

WAC 51-11C-40410 Section C404.10--Pools and in-ground spas.

- C404.10 Pools and in-ground permanently installed spas (mandatory). Pools and in-ground permanently installed spas shall comply with Sections C404.10.1 through C404.10.4.
- **C404.10.1 Heaters.** Heat pump pool heaters shall have a minimum COP of 4.0 determined in accordance with ASHRAE Standard 146. Other pool heating equipment shall comply with the applicable efficiencies in Section C404.2.3.

All heaters shall be equipped with a readily accessible on-off switch that is mounted outside of the heater to allow shutting off the heater without adjusting the thermostat setting. Gas-fired heaters shall not be equipped with constant burning pilot lights.

C404.10.2 Time switches. Time switches or other control method that can automatically turn off and on heaters and pumps according to a preset schedule shall be installed on all heaters and pumps. Heaters, pumps and motors that have built in timers shall be deemed in compliance with this requirement.

EXCEPTIONS:

- 1. Where public health standards require 24-hour pump operation.
- 2. Where pumps are required to operate solar- and waste-heat-recovery pool heating systems.
- **C404.10.3 Covers.** Heated pools and in-ground permanently installed spas shall be provided with a vapor-retardant cover on or at the water surface. Pools heated to more than 90°F shall have a pool cover with a minimum insulation value of R-12, and the sides and bottom of the pool shall also have a minimum insulation value of R-12.
- **C404.10.4 Heat recovery.** Heated indoor swimming pools, spas or hot tubs with water surface area greater than 200 square feet shall provide for energy conservation by an exhaust air heat recovery system that heats ventilation air, pool water or domestic hot water. The heat recovery system shall be capable of decreasing the exhaust air temperature at design heating conditions (80°F indoor) by 36°F (10°C) in Climate Zones 4C and 5B and 48°F (26.7°C) in Climate Zone 6B.

EXCEPTION:

 $Pools, spas \ or \ hot \ tubs \ that \ include \ system(s) \ that \ provide \ equivalent \ recovered \ energy \ on \ an \ annual \ basis \ through \ one \ of \ the \ following \ methods:$

- 1. Renewable energy;
- 2. Dehumidification heat recovery;
- 3. Waste heat recovery; or
- 4. A combination of these system sources capable of providing at least 70 percent of the heating energy required over an operating season.

WAC 51-11C-40500 Section C405--Electrical power and lighting systems.

NEW SECTION

WAC 51-11C-40501 Section C405.1--General.

C405.1 General (mandatory). This section covers lighting system controls, the connection of ballasts, the maximum lighting power for interior applications, electrical energy consumption, minimum acceptable lighting equipment for exterior applications, and minimum efficiencies for motors and transformers.

EXCEPTION:

Dwelling units within commercial buildings shall not be required to comply with Sections C405.2 through C405.5 provided that a minimum of 75 percent of the lamps in permanently installed light fixtures shall be high efficacy lamps

Walk-in coolers and walk-in freezers shall comply with C405.10. Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with C405.11.

NEW SECTION

WAC 51-11C-40502 Section C405.2--Electrical power and lighting systems.

C405.2 Lighting controls (mandatory). Lighting systems shall be provided with controls as specified in Sections C405.2.1, C405.2.2, C405.2.3, C405.2.4 and C405.2.5.

EXCEPTION:

Industrial or manufacturing process areas, as may be required for production and safety.

NEW SECTION

WAC 51-11C-405021 Section C405.2.1--Manual lighting controls.

C405.2.1 Manual lighting controls. All buildings shall include manual lighting controls that meet the requirements of Sections C405.2.1.1 and C405.2.1.2.

C405.2.1.1 Interior lighting controls. Each area enclosed by walls or floor-to-ceiling partitions shall have at least one manual control for the lighting serving that area. The required controls shall be located within the area served by the controls or be a remote switch that identifies the lights served and indicates their status.

EXCEPTIONS:

- 1. Areas designated as security or emergency areas that need to be continuously lighted.
- 2. Lighting in stairways or corridors that are elements of the means of egress.
- **C405.2.1.2 Light reduction controls.** Each area that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent. Lighting reduction shall be achieved by one of the following or other approved method:
 - 1. Controlling all lamps or luminaires;
- 2. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps;
- 3. Switching the middle lamp luminaires independently of the outer lamps; or
 - 4. Switching each luminaire or each lamp.

EXCEPTION:

Light reduction controls need not be provided in the following areas and spaces:

- 1. Areas that have only one luminaire, with rated power less than 100 watts.
- 2. Areas that are controlled by an occupant-sensing device.
- 3. Corridors, equipment rooms, storerooms, restrooms, public lobbies, electrical or mechanical rooms.
- 4. Sleeping unit (see Section C405.2.3).
- 5. Spaces that use less than 0.6 watts per square foot (6.5 W/m^2) .
- 6. Daylight spaces complying with Section C405.2.2.3.2.

NEW SECTION

WAC 51-11C-405022 Section C405.2.2--Additional lighting controls.

C405.2.2 Additional lighting controls. Each area that is required to have a manual control shall also have controls that meet the requirements of Sections C405.2.2.1, C405.2.2.2 and C405.2.2.3.

EXCEPTION:

Additional lighting controls need not be provided in the following spaces:

- 1. Sleeping units.
- 2. Spaces where patient care is directly provided.
- $3.\ Spaces\ where\ an\ automatic\ shutoff\ would\ endanger\ occupant\ safety\ or\ security.$
- 4. Lighting intended for continuous operation.
- C405.2.2.1 Automatic time switch control devices. Automatic time switch controls shall be installed to control lighting in all areas of the building. Automatic time switches shall have a minimum 7 day clock and be capable of being set for 7 different day types per week and incorporate an automatic holiday "shut-off" feature, which turns off all loads for at least 24 hours and then resumes normally scheduled operations. Automatic time switches shall also have program back-up capabilities, which prevent the loss of program and time settings for at least 10 hours, if power is interrupted.

EXCEPTIONS:

- 1. Emergency egress lighting does not need to be controlled by an automatic time switch.
- 2. Lighting in spaces controlled by occupancy sensors does not need to be controlled by automatic time switch controls.

The automatic time switch control device shall include an override switching device that complies with the following:

- 1. The override switch shall be in a readily accessible location;
- 2. The override switch shall be located where the lights controlled by the switch are visible; or the switch shall provide a mechanism which announces the area controlled by the switch;
 - 3. The override switch shall permit manual operation;
- 4. The override switch, when initiated, shall permit the controlled lighting to remain on for a maximum of 2 hours; and
- 5. Any individual override switch shall control the lighting for a maximum area of 5,000 square feet (465 m^2) .

EXCEPTION:

Within malls, arcades, auditoriums, single tenant retail spaces, industrial facilities and arenas:

- 1. The time limit shall be permitted to exceed 2 hours provided the override switch is a captive key device; and 2. The area controlled by the override switch is permitted to exceed 5,000 square feet (465 m^2) , but shall not exceed 20,000 square feet (1860 m^2) .
- **C405.2.2.2 Occupancy sensors.** Occupancy sensors shall be installed in all classrooms, conference/meeting rooms, employee lunch and break rooms, private offices, restrooms, warehouse spaces, storage rooms and janitorial closets, and other spaces 300 square feet (28 $\rm m^2$) or less enclosed by floor-to-ceiling height partitions. These automatic control devices shall be installed to automatically turn off lights within 30 minutes of all occupants leaving the space, and shall either be manual on or shall be controlled to automatically turn the lighting on to not more than 50 percent power.

EXCEPTION:

Full automatic-on controls shall be permitted to control lighting in public corridors, stairways, restrooms, primary building entrance areas and lobbies, and areas where manual-on operation would endanger the safety or security of the room or building occupants.

- C405.2.2.3 Daylight zone control. Daylight zones shall be designed such that lights in the daylight zone are controlled independently of general area lighting and are controlled in accordance with Section C405.2.2.3.2. Each daylight control zone shall not exceed 2,500 square feet (232 m²). Contiguous daylight zones adjacent to vertical fenestration are allowed to be controlled by a single controlling device provided that they do not include zones facing more than two adjacent cardinal orientations (i.e., north, east, south, west). The primary daylight zone shall be controlled separately from the secondary daylight zone. Daylight zones under skylights more than 15 feet (4572 mm) from the perimeter shall be controlled separately from daylight zones adjacent to vertical fenestration. Controls shall:
 - 1. Control only luminaires within the daylit area.
- 2. Incorporate time-delay circuits to prevent cycling of light level changes of less than three minutes.

EXCEPTION:

Daylight zones enclosed by walls or ceiling height partitions and containing two or fewer light fixtures are not required to have a separate switch for general area lighting.

C405.2.2.3.1 Reserved.

C405.2.2.3.2 Automatic daylighting controls. Setpoint and other controls for calibrating the lighting control device shall be readily accessible.

Daylighting controls device shall be capable of automatically reducing the lighting power in response to available daylight by either one of the following methods:

- 1. Continuous dimming using dimming ballasts and daylight-sensing automatic controls that are capable of reducing the power of general lighting in the daylit zone continuously to less than 20 percent of rated power at maximum light output.
- 2. Stepped dimming using multi-level switching and daylight-sensing controls that are capable of reducing lighting power automatically. The system shall provide a minimum of two control channels per zone and be installed in a manner such that at least one control step is between 50 percent and 70 percent of design lighting power and another control step is no greater than 35 percent of design power, and the system is capable of automatically turning the system off.

C405.2.2.3.3 Reserved.

NEW SECTION

WAC 51-11C-405023 Section C405.2.3--Specific application controls.

- **C405.2.3 Specific application controls.** Specific application controls shall be provided for the following:
- 1. Display and accent light shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.
- 2. Lighting in cases used for display case purposes shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.
- 3. Hotel and motel sleeping units and guest suites shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles. Where a hotel/motel includes more than 50 rooms, controls shall be automatic to ensure all power to the lights and switched outlets are turned off when the occupant is not in the room.
- 4. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting, shall be automatically shut off whenever that space is unoccupied and shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device is readily accessible.
- 5. Lighting for nonvisual applications, such as plant growth and food warming, shall be controlled by a dedicated control which is independent of the controls for other lighting within the room

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or space.

- 6. Lighting equipment that is for sale or for demonstrations in lighting education shall be controlled by a dedicated control which is independent of the controls for other lighting within the room or space.
- 7. Luminaires serving the exit access and providing means of egress illumination required by Section 1006.1 of the *International Building Code*, including luminaires that function as both normal and emergency means of egress illumination shall be controlled by a combination of listed emergency relay and occupancy sensors, or signal from another building control system, that automatically shuts off the lighting when the areas served by that illumination are unoccupied.

EXCEPTION:

Means of egress illumination serving the exit access that does not exceed 0.05 watts per square foot of building area is exempt from this requirement.

NEW SECTION

WAC 51-11C-405024 Section C405.2.4--Exterior lighting controls.

C405.2.4 Exterior lighting controls. Lighting not designated for dusk-to-dawn operation shall be controlled by either a combination of a photosensor and a time switch, or an astronomical time switch. Lighting designated for dusk-to-dawn operation shall be controlled by an astronomical time switch or photosensor. All time switches shall be capable of retaining programming and the time setting during loss of power for a period of at least 10 hours.

NEW SECTION

WAC 51-11C-405025 Section C405.2.5--Area controls.

C405.2.5 Area controls. The maximum lighting power that may be controlled from a single switch or automatic control shall not exceed that which is provided by a 20 ampere circuit loaded to not more than 80 percent. A master control may be installed provided the individual switches retain their capability to function independently. Circuit breakers may not be used as the sole means of switching.

EXCEPTION:

Areas less than 5 percent of the building footprint for footprints over 100,000 ft².

WAC 51-11C-40503 Section C405.3--Reserved.

C405.3 Reserved.

NEW SECTION

WAC 51-11C-40504 Section C405.4--Exit signs.

C405.4 Exit signs (mandatory). Internally illuminated exit signs shall not exceed 5 watts per side.

NEW SECTION

WAC 51-11C-40505 Section C405.5--Interior lighting power requirements.

C405.5 Interior lighting power requirements (prescriptive). A building complies with this section if its total connected lighting power calculated under Section C405.5.1 is no greater than the interior lighting power calculated under Section C405.5.2.

NEW SECTION

WAC 51-11C-405051 Section C405.5.1--Total connected interior lighting power.

C405.5.1 Total connected interior lighting power. The total connected interior lighting power (watts) shall be the sum of the watts of all interior lighting equipment as determined in accordance with Sections C405.5.1.1 through C405.5.1.4.

EXCEPTIONS:

- 1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
- 1.1. Professional sports arena playing field lighting.
- 1.2. Emergency lighting automatically off during normal building operation.
- 1.3. Lighting in spaces specifically designed for use by occupants with special lighting needs including the visually impaired and other medical and age-related issues.
- 1.4. Casino gaming areas.
- 1.5. General area lighting power in industrial and manufacturing occupancies dedicated to the inspection or quality control of goods and products.
- 2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device:
- 2.1. Task lighting for medical and dental purposes.

- 2.2. Display lighting for exhibits in galleries, museums and monuments.
- 3. Lighting for theatrical purposes, including performance, stage, film production and video production.
- 4. Lighting for photographic processes.
- 5. Lighting integral to equipment or instrumentation and is installed by the manufacturer.
- 6. Task lighting for plant growth or maintenance.
- 7. Advertising signage or directional signage.
- 8. In restaurant buildings and areas, lighting for food warming or integral to food preparation equipment.
- 9. Lighting equipment that is for sale.
- 10. Lighting demonstration equipment in lighting education facilities.
- 11. Lighting *approved* because of safety or emergency considerations, inclusive of exit lights.
- 12. Lighting integral to both open and glass enclosed refrigerator and freezer cases.
- 13. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
- 14. Furniture mounted supplemental task lighting that is controlled by automatic shutoff.
- 15. Lighting used for aircraft painting.
- **C405.5.1.1 Screw lamp holders.** The wattage shall be the maximum *labeled* wattage of the luminaire.
- **C405.5.1.2 Low-voltage lighting.** The wattage shall be the specified wattage of the transformer supplying the system.
- **C405.5.1.3 Other luminaires.** The wattage of all other lighting equipment shall be the wattage of the lighting equipment verified through data furnished by the manufacturer or other *approved* sources.
- C405.5.1.4 Line-voltage lighting track and plug-in busway. The wattage shall be:
- 1. The specified wattage of the luminaires included in the system with a minimum of 50 W/lin ft. (162 W/lin. m);
 - 2. The wattage limit of the system's circuit breaker; or
- 3. The wattage limit of other permanent current limiting device(s) on the system.

WAC 51-11C-405052 Section C405.5.2--Interior lighting power requirements.

C405.5.2 Interior lighting power. The total interior lighting power allowance (watts) is determined according C405.5.2(1) using the Building Area Method, or Table C405.5.2(2) using the Space-by-Space Method, for all areas of the building covered in this permit. For the Building Area Method, the interior lighting power allowance is the floor area for each building area type listed in Table C405.5.2(1) times the value from Table C405.5.2(1) for that area. For the purposes of this method, an "area" shall be defined as all contiguous spaces that accommodate or are associated with a single building area type as listed in Table C405.5.2(1). Where this method is used to calculate the total interior lighting power for an entire building, each building area type shall be treated as a separate area. For the Space-by-Space Method, the interior lighting power allowance is determined by multiplying the floor area of each space times the value for the

space type in Table C405.5.2(2) that most closely represents the proposed use of the space, and then summing the lighting power allowances for all spaces. Tradeoffs among spaces are permitted.

NEW SECTION

WAC 51-11C-405053 Table C405.5.2(1)--Interior lighting power allowances--Building area method.

Table C405.5.2(1)
Interior Lighting Power Allowances--Building Area Method

	I DD
Building Area Type	LPD (w/ft²)
Automotive facility	0.82
Convention center	1.08
Court house	1.05
Dining: Bar lounge/leisure	0.99
Dining: Cafeteria/fast food	0.90
Dining: Family	0.89
Dormitory	0.61
Exercise center	0.88
Fire station	0.71
Gymnasium	0.95
Health care clinic	0.87
Hospital	1.20
Hotel	1.00
Library	1.18
Manufacturing facility	1.11
Motel	0.88
Motion picture theater	0.83
Multifamily	0.60
Museum	1.00
Office	0.90
Parking garage	0.20
Penitentiary	0.90
Performing arts theater	1.25
Police station	0.90
Post office	0.87
Religious building	1.05
Retail	1.33
School/university	0.99
Sports arena	0.78
Town hall	0.92
Transportation	0.77

Building Area Type	LPD (w/ft²)
Warehouse	0.50
Workshop	1.20

WAC 51-11C-405054 Table C405.5.5.2(2)--Interior lighting power allowances--Space-by-space method.

Table C405.5.2(2)
Interior Lighting Power Allowances--Space-by-Space Method

Common Space-by-Space Types	LPD (w/ft²)	
Atrium - First 40 feet in height	0.03 per ft. ht.	
Atrium - Above 40 feet in height	0.02 per ft. ht.	
Audience/seating area - Permanent		
For auditorium	0.79	
For performing arts theater	2.43	
For motion picture theater	1.14	
Classroom/lecture/training	1.24	
Conference/meeting/multipurpose	1.23	
Corridor/transition	0.66	
Dining area		
Bar/lounge/leisure dining	1.31	
Family dining area	0.89	
Dressing/fitting room performing arts theater	0.40	
Electrical/mechanical	0.95	
Food preparation	0.99	
Laboratory for classrooms	1.28	
Laboratory for	1.81	
medical/industrial/research	1.01	
Lobby	0.90	
Lobby for performing arts theater	2.00	
Lobby for motion picture theater	0.52	
Locker room	0.75	
Lounge recreation	0.73	
Office - Enclosed	1.11	
Office - Open plan	0.98	
Restroom	0.98	
Sales area	1.68 ^a	
Stairway	0.69	
Storage	0.63	

Common Space-by-Space Types	LPD (w/ft²)			
Workshop	1.59			
Building Specific Space-by-space Types				
Automotive - Service/repair	0.67			
Bank/office - Banking activity area	1.38			
Convention center				
Exhibit space	1.45			
Audience/seating area	0.82			
Courthouse/police				
station/penitentiary				
Courtroom	1.72			
Confinement cells	1.10			
Judge chambers	1.17			
Penitentiary audience	0.43			
seating	1.24			
Penitentiary classroom	1.34			
Penitentiary dining	1.07			
Dormitory living quarters	0.38			
Fire stations	0.74			
Engine rooms	0.56			
Sleeping quarters	0.25			
Gymnasium/fitness center				
Fitness area	0.72			
Gymnasium	0.43			
audience/seating	1.20			
Playing area	1.20			
Health care clinic/hospital Corridors/transition	0.80			
	0.89			
Emergency	2.26			
Exam/treatment	1.66			
Medical supplies	1.27			
Nursery	0.88			
Nurse station	0.87			
Operating room	1.89			
Patient room	0.62			
Pharmacy	1.14			
Physical therapy	0.91			
Radiology/imaging	1.32			
Recovery	1.15			
Hotel	0.02			
Dining area	0.82			
Guest rooms	1.11			
Hotel lobby	1.06			
Highway lodging dining	0.88			
Highway lodging guest	0.75			
rooms				

Comm	on Space-by-Space Types	LPD (w/ft²)
Library		
	Card file and cataloguing	0.72
	Reading area	0.93
	Stacks	1.71
Manufac	cturing	
	Corridors/transition	0.41
	Detailed manufacturing	1.29
	Equipment room	0.95
	Extra high bay (> 50-foot floor-ceiling height)	1.05
	High bay (25 - 50-foot floor-ceiling height)	1.23
	Low bay (< 25-foot floor-ceiling height)	1.19
Museum	1	
	General exhibition	1.05
	Restoration	1.02
Parking	garage - Garage areas	0.19
Post offi	ce	
	Sorting area	0.94
Religiou	s building	
	Audience seating	1.53
	Fellowship hall	0.64
	Worship pulpit/choir	1.53
Retail		
	Dressing/fitting area	0.87
	Mall concourse	1.10
	Sales area	1.68ª
Sports a	rena	
	Audience seating	0.43
	Court sports area - Class 4	0.72
	Court sports area - Class 3	1.20
	Court sports area - Class 2	1.92
	Court sports area - Class 1	3.01
	Ring sports area	2.68
Transpo	rtation	
	Air/train/bus baggage area	0.76
	Airport concourse	0.36
	Audience seating	0.54
	Terminal - Ticket counter	1.08
Warehou	ıse	
	Fine material storage	0.95
	Medium/bulky material	0.58

For SI: 1 foot = 304.8 mm, 1 watt per square foot = 11 W/m². ^aWhere lighting equipment is specified to be installed to highlight specific merchandise in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller

of the actual wattage of the lighting equipment installed specifically for merchandise, or additional lighting power as determined below shall be added to the interior lighting power determined in accordance with this line item.

Calculate the additional lighting power as follows:

Additional Interior = $500 \text{ watts} + (\text{Retail Area } 1 \times 0.6 \text{ W/ft}^2) + (\text{Retail Area } 2 \times 0.6 \text{ W/ft}^2) + (\text{Retail Area } 2 \times 0.6 \text{ W/ft}^2) + (\text{Retail Area } 4 \times 2.5 \text{ W/ft}^2).$ Allowance Allowance

Where:

Retail Area 1 = The floor area for all products not listed in Retail Area 2, 3 or 4.

Retail Area 2 = The floor area used for the sale of vehicles, sporting goods and small electronics.

Retail Area 3 = The floor area used for the sale of furniture, clothing, cosmetics and artwork.

Retail Area 4 = The floor area used for the sale of jewelry, crystal and china.

EXCEPTION:

Other merchandise categories are permitted to be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is *approved* by the authority having jurisdiction.

NEW SECTION

WAC 51-11C-40506 Section C405.6--Exterior lighting.

C405.6 Exterior lighting (mandatory). Where the power for exterior lighting is supplied through the energy service to the building, all exterior lighting shall comply with Sections C405.6.1 and C405.6.2.

EXCEPTION:

Where approved because of historical, safety, signage or emergency considerations.

NEW SECTION

WAC 51-11C-405061 Section C405.6.1--Exterior building grounds lighting.

C405.6.1 Exterior building grounds lighting. All exterior building grounds luminaires that operate at greater than 100 watts shall contain lamps having a minimum efficacy of 60 lumens per watt unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under Section C405.6.2.

WAC 51-11C-405062 Section C405.6.2--Exterior building lighting power.

C405.6.2 Exterior building lighting power. The total exterior lighting power allowance for all exterior building applications is the sum of the base site allowance plus the individual allowances for areas that are to be illuminated and are permitted in Table C405.6.2(2) for the applicable lighting zone. Tradeoffs are allowed only among exterior lighting applications listed in Table C405.6.2(2), Tradable Surfaces section. The lighting zone for the building exterior is determined from Table C405.6.2(1) unless otherwise specified by the local jurisdiction. Exterior lighting for all applications (except those included in the exceptions to Section C405.6.2) shall comply with the requirements of Section C405.6.1.

EXCEPTION:

Lighting used for the following exterior applications is exempt where equipped with a control device independent of the control of the nonexempt lighting:

- 1. Specialized signal, directional and marker lighting associated with transportation;
- 2. Advertising signage or directional signage;
- 3. Integral to equipment or instrumentation and is installed by its manufacturer;
- 4. Theatrical purposes, including performance, stage, film production and video production;
- 5. Athletic playing areas;
- 6. Temporary lighting;
- 7. Industrial production, material handling, transportation sites and associated storage areas;
- 8. Theme elements in theme/amusement parks; and
- 9. Used to highlight features of public monuments and registered historic landmark structures or buildings.

NEW SECTION

WAC 51-11C-405063 Table C405.6.2(1)--Exterior lighting zones.

Table C405.6.2(1)
Exterior Lighting Zones

Lighting Zone	Description
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

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WAC 51-11C-405064 Table C405.6.2(2)--Individual lighting power allowances for building exteriors.

Table C405.6.2(2)
Individual Lighting Power Allowances for Building Exteriors

		Lighting Zones			
		Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (Base allowance is usable in tradable or nontradable surfaces.)		500 W	600 W	750 W	1300 W
Tradable Surfaces		Uncovered Pa	arking Areas		
(Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas are tradable.)	Parking areas and drives	0.04 W/ft ²	0.06 W/ft ²	0.10 W/ft ²	0.13 W/ft ²
		Building	Grounds		
	Walkways less than 10 feet wide	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
	Walkways 10 feet wide or greater, plaza areas, special feature areas	0.14 W/ft ²	0.14 W/ft ²	0.16 W/ft ²	0.2 W/ft ²
	Stairways	0.75 W/ft ²	1.0 W/ft ²	1.0 W/ft ²	1.0 W/ft ²
	Pedestrian tunnels	0.15 W/ft ²	0.15 W/ft ²	0.2 W/ft ²	0.3 W/ft ²
		Building Entra	nces and Exits		•
	Main entries	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry canopies	0.25 W/ft ²	0.25 W/ft ²	0.4 W/ft ²	0.4 W/ft ²
	Sales Canopies				
	Free standing and attached	0.6 W/ft ²	0.6 W/ft ²	0.8 W/ft ²	1.0 W/ft ²
		Outdoo	r Sales		
	Open areas (including vehicle sales lots)	0.25 W/ft ²	0.25 W/ft ²	0.5 W/ft ²	0.7 W/ft ²
	Street frontage for vehicle sales lots in addition to "open area" allowance	No Allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot
Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building facades	No allowance	0.1 W/ft² for each illuminated wall or surface or 2.5 W/linear foot for each illuminated wall or surface length	0.15 W/ft ² for each illuminated wall or surface or 3.75 W/linear foot for each illuminated wall or surface length	0.2 W/ft² for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length

	Lighting Zones			
	Zone 1	Zone 2	Zone 3	Zone 4
Automated teller machines and night depositories	270 W per location plus 90 W per additional ATM per location			
Entrances and gatehouse inspection stations at guarded facilities	0.75 W/ft ² of covered and uncovered area	0.75 W/ft ² of covered and uncovered area	0.75 W/ft ² of covered and uncovered area	0.75 W/ft ² of covered and uncovered area
Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft ² of covered and uncovered area	0.5 W/ft ² of covered and uncovered area	0.5 W/ft ² of covered and uncovered area	0.5 W/ft ² of covered and uncovered area
Drive-up windows/doors	400 W per drive- through	400 W per drive- through	400 W per drive- through	400 W per drive- through
Parking near 24-hour retail entrances	800 W per main entry			

For SI: 1 foot = 304.8 mm, 1 watt per square foot = $W/0.0929 \text{ m}^2$

WAC 51-11C-40507 Section C405.7--Electrical energy consumption.

C405.7 Electrical energy consumption (mandatory). In buildings having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units. A utility tenant meter meets this requirement.

NEW SECTION

WAC 51-11C-40508 Section C405.8--Electric motors.

 ${\tt C405.8}$ Electric motors. All permanently wired polyphase motors of 1 hp or more, which are not part of an HVAC system, shall comply with Section C403.2.13.

EXCEPTIONS:

- 1. Motors that are an integral part of specialized process equipment.
- 2. Where the motor is integral to a listed piece of equipment for which no complying motor has been approved.

WAC 51-11C-40509 Section C405.9--Transformers.

C405.9 Transformers. The minimum efficiency of a low voltage drytype distribution transformer shall be the Class I Efficiency Levels for distribution transformers specified in Table 4-2 of NEMA TP-1.

NEW SECTION

WAC 51-11C-40510 Section C405.10--Walk-in coolers and freezers.

C405.10 Walk-in coolers and walk-in freezers. Walk-in coolers and walk-in freezers shall comply with all of the following:

1. Lights shall use light sources with an efficacy of 40 lumens per watt or more, including ballast losses (if any). Light sources with an efficacy of less than 40 lumens per watt, including ballast losses (if any), may be used in conjunction with a timer or device that turns off the lights within 15 minutes of when the walk-in cooler or walk-in freezer is not occupied by people.

NEW SECTION

WAC 51-11C-40511 Section C405.11--Refrigerated warehouse coolers and freezers.

- **C405.11 Refrigerated warehouse coolers and refrigerated warehouse freezers.** Refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with all of the following:
- 1. Lights shall use light sources with an efficacy of 40 lumens per watt or more, including ballast losses (if any). Light sources with an efficacy of less than 40 lumens per watt, including ballast losses (if any), may be used in conjunction with a timer or device that turns off the lights within 15 minutes of when the refrigerated warehouse cooler or refrigerated warehouse freezer is not occupied by people.

WAC 51-11C-40512 Section C405.12--Escalators and moving walks.

C405.12 Escalators and moving walks.

C405.12.1 Variable speed escalators. Where variable speed escalators and moving walks are permitted by the administrative authority, all escalators and moving walks shall reduce their operating speed to no more than 15 feet per minute when no passengers have been detected for a period of time not exceeding three times the amount of time required to transfer a passenger between landings. Such escalators and moving walks shall comply with the requirements of ANSI/ASME A17.1 for variable speed escalators and moving walks.

EXCEPTION: A power factor controller that reduces operating voltage in response to light loading conditions may be provided in place of the variable speed function.

C405.12.2 Regenerative drive. Escalators designed either for one-way down operation only or for reversible operation shall have variable frequency regenerative drives that supply electrical energy to the building electrical system when loaded with more than 5 passengers.

NEW SECTION

WAC 51-11C-40513 Section C405.13--Electrical power and lighting systems commissioning and completion requirements.

C405.13 Electrical power and lighting systems commissioning and completion requirements. Electrical power and lighting systems shall be commissioned and completed in accordance with Section C408.

NEW SECTION

WAC 51-11C-40600 Section C406--Additional efficiency package options.

Sections C406.1 through C406.4 are not adopted.

WAC 51-11C-40700 Section C407--Total building performance.

NEW SECTION

WAC 51-11C-40701 Section C407.1--Scope.

C407.1 Scope. This section establishes criteria for compliance using total building performance. All systems and loads shall be included in determining the total building performance including, but not limited to: Heating systems, cooling systems, service water heating, fan systems, lighting power, receptacle loads and process loads.

NEW SECTION

WAC 51-11C-40702 Section C407.2--Mandatory requirements.

C407.2 Mandatory requirements. Compliance with this section requires that the criteria of Sections C402.4, C403.2, C404 and C405 be met.

The building permit application for projects utilizing this method shall include in one submittal all building and mechanical drawings and all information necessary to verify that the building envelope and mechanical design for the project corresponds with the annual energy analysis. If credit is proposed to be taken for lighting energy savings, then an electrical permit application shall also be submitted and approved prior to the issuance of the building permit. If credit is proposed to be taken for energy savings from other components, then the corresponding permit application (e.g., plumbing, boiler, etc.) shall also be submitted and approved prior to the building permit application. Otherwise, components of the project that would not be approved as part of a building permit application shall be modeled the same in both the proposed building and the *standard reference design* and shall comply with the requirements of this code.

- WAC 51-11C-40703 Section C407.3--Performance-based compliance.
- **C407.3 Performance-based compliance.** Compliance based on total building performance requires that a proposed building (*proposed design*) be shown to have an annual energy consumption based on site energy expressed in Btu and Btu per square foot of *conditioned floor area* that is less than or equal to the annual energy consumption of the *standard reference design*.

NEW SECTION

WAC 51-11C-40704 Section C407.4--Documentation.

- **C407.4 Documentation.** Documentation verifying that the methods and accuracy of compliance software tools conform to the provisions of this section shall be provided to the *code official*.
- **C407.4.1 Compliance report.** Building permit submittals shall include a report that documents that the *proposed design* has annual energy consumption less than or equal to the annual energy consumption of the *standard reference design*. The compliance documentation shall include the following information:
 - 1. Address of the building;
- 2. An inspection checklist documenting the building component characteristics of the *proposed design* as *listed* in Table C407.5.1(1). The inspection checklist shall show the estimated annual energy consumption for both the *standard reference design* and the *proposed design*;
 - 3. Name of individual completing the compliance report; and
 - 4. Name and version of the compliance software tool.
- **C407.4.2 Additional documentation.** The *code official* shall be permitted to require the following documents:
- 1. Documentation of the building component characteristics of the *standard reference design*;
- 2. Thermal zoning diagrams consisting of floor plans showing the thermal zoning scheme for *standard reference design* and *proposed design*;
- 3. Input and output report(s) from the energy analysis simulation program containing the complete input and output files, as applicable. The output file shall include energy use totals and energy use by energy source and end-use served, total hours that space conditioning loads are not met and any errors or warning messages generated by the simulation tool as applicable;
- 4. An explanation of any error or warning messages appearing in the simulation tool output; and
 - 5. A certification signed by the builder providing the

building component characteristics of the $proposed\ design$ as given in Table C407.5.1(1).

NEW SECTION

WAC 51-11C-40705 Section C407.5--Calculation procedure.

- **C407.5 Calculation procedure.** Except as specified by this section, the *standard reference design* and *proposed design* shall be configured and analyzed using identical methods and techniques.
- **C407.5.1 Building specifications.** The standard reference design and proposed design shall be configured and analyzed as specified by Table C407.5.1(1). Table C407.5.1(1) shall include by reference all notes contained in Table C402.2.
- **C407.5.2 Thermal blocks.** The *standard reference design* and *proposed design* shall be analyzed using identical thermal blocks as specified in Section C407.5.2.1, C407.5.2.2 or C407.5.2.3.
- ${\tt C407.5.2.1}$ HVAC zones designed. Where HVAC zones are defined on HVAC design drawings, each HVAC zone shall be modeled as a separate thermal block.

EXCEPTION:

Different HVAC *zones* shall be allowed to be combined to create a single thermal block or identical thermal blocks to which multipliers are applied provided:

- 1. The space use classification is the same throughout the thermal block.
- 2. All HVAC *zones* in the thermal block that are adjacent to glazed exterior walls face the same orientation or their orientations are within 45 degrees (0.79 rad) of each other.
- 3. All of the zones are served by the same HVAC system or by the same kind of HVAC system.
- **C407.5.2.2 HVAC zones not designed.** Where HVAC zones have not yet been designed, thermal blocks shall be defined based on similar internal load densities, occupancy, lighting, thermal and temperature schedules, and in combination with the following quidelines:
- 1. Separate thermal blocks shall be assumed for interior and perimeter spaces. Interior spaces shall be those located more than 15 feet (4572 mm) from an exterior wall. Perimeter spaces shall be those located closer than 15 feet (4572 mm) from an exterior wall.
- 2. Separate thermal blocks shall be assumed for spaces adjacent to glazed exterior walls: A separate zone shall be provided for each orientation, except orientations that differ by no more than 45 degrees (0.79 rad) shall be permitted to be considered to be the same orientation. Each zone shall include floor area that is 15 feet (4572 mm) or less from a glazed perimeter wall, except that floor area within 15 feet (4572 mm) of glazed perimeter walls having more than one orientation shall be divided proportionately between zones.
- 3. Separate thermal blocks shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features.

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- 4. Separate thermal blocks shall be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.
- **C407.5.2.3 Multifamily residential buildings.** Residential spaces shall be modeled using one thermal block per space except that those facing the same orientations are permitted to be combined into one thermal block. Corner units and units with roof or floor loads shall only be combined with units sharing these features.

WAC 51-11C-407051 Table C407.5.1(1)--Specifications for the standard reference and proposed design.

Table C407.5.1(1)
Specifications for the Standard Reference and Proposed Designs

Building Component		
Characteristics	Standard Reference Design	Proposed Design
Space use classification	Same as proposed	The space use classification shall be chosen in accordance with Table C405.5.2 for all areas of the building covered by this permit. Where the space use classification for a building is not known, the building shall be categorized as an office building.
Roofs	Type: Insulation entirely above deck	As proposed
	Gross area: Same as proposed	As proposed
	<i>U</i> -factor: From Table C402.1.2	As proposed
	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, above-grade	Type: Mass wall if proposed wall is mass; otherwise steel-framed wall	As proposed
	Gross area: Same as proposed	As proposed
	<i>U</i> -factor: From Table C402.1.2	As proposed
	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, below-grade	Type: Mass wall	As proposed
	Gross area: Same as proposed	As proposed
	U-Factor: From Table C402.1.2 with insulation layer on interior side of walls	As proposed
Floors, above-grade	Type: Joist/framed floor	As proposed
	Gross area: Same as proposed	As proposed
	<i>U</i> -factor: From Table C402.1.2	As proposed
Floors, slab-on-grade	Type: Unheated	As proposed

Building Component Characteristics	Standard Reference Design	Proposed Design
	F-factor: From Table C402.1.2	As proposed
Doors	Type: Swinging	As proposed
	Area: Same as proposed	As proposed
	<i>U</i> -factor: From Table C402.2	As proposed
Vertical Fenestration	Area	As proposed
	1. The proposed vertical fenestration area; where the proposed vertical fenestration area is less than 30 percent of above-grade wall area.	
	2. 30 percent of above-grade wall area; where the proposed vertical fenestration area is 30 percent or more of the above-grade wall area.	
	<i>U</i> -factor: From Table C402.3 for the same framing material as proposed	As proposed
	SHGC: From Table C402.3 except that for climates with no requirement (NR) SHGC = 0.40 shall be used	As proposed
	External shading and PF: None	As proposed
Skylights	1. The proposed skylight area; where the proposed skylight area is less than 3 percent of gross area of roof assembly.	As proposed
	2. 3 percent of gross area of roof assembly; where the proposed skylight area is 3 percent or more of gross area of roof assembly.	
	<i>U</i> -factor: From Table C402.3	As proposed
	SHGC: From Table C402.3 except that for climates with no requirement (NR) SHGC = 0.40 shall be used	As proposed
Lighting, interior	The interior lighting power shall be determined in accordance with Table C405.5.2. Where the occupancy of the building is not known, the lighting power density shall be 1.0 watt per square foot (10.73 W/m²) based on the categorization of buildings with unknown space classification as offices.	As proposed
	Automatic lighting controls (e.g., programmable controls or automatic controls for daylight utilization) shall be modeled in <i>the standard reference design</i> as required by Section C405.	
Lighting, exterior	The lighting power shall be determined in accordance with Table C405.6.2(2). Areas and dimensions of tradable and nontradable surfaces shall be the same as proposed.	As proposed

Building Component Characteristics	Standard Reference Design	Proposed Design
Internal gains	Same as proposed	Receptacle, motor and process loads shall be modeled and estimated based on the space use classification. All end-use load components within and associated with the building shall be modeled to include, but not be limited to, the following: Exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators, escalators, refrigeration equipment and cooking equipment.
Schedules	Same as proposed	Operating schedules shall include hourly profiles for daily operation and shall account for variations between weekdays, weekends, holidays and any seasonal operation. Schedules shall model the time-dependent variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads. The schedules shall be typical of the proposed building type as determined by the designer and approved by the jurisdiction.
Mechanical ventilation	Same as proposed, except when modeling demand-control ventilation in the proposed design when its use is not required by Section C403.2.5.1 or occupancy sensor ventilation controls when their use is not required by Section C403.2.5.2.	As proposed, in accordance with Section C403.2.5.
Heating systems	Fuel type: Same as proposed design	As proposed
	Equipment type ^a : From Tables C407.5.1(2) and C407.5.1(3)	As proposed
	Efficiency: From Tables C403.2.3(2), C403.2.3(3), C403.2.3(4) and C403.2.3(5) Preheat coils: If the HVAC system in the proposed design has a preheat coil and a preheat coil can be modeled in the <i>standard reference design</i> , the <i>standard reference design</i> shall be modeled with a preheat coil controlled in the same manner as the proposed design.	As proposed

Building Component Characteristics	Standard Reference Design	Proposed Design
Characteristics	Capacity ^b : Sized proportionally to the capacities in the proposed design based on sizing runs, i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be the same for both the proposed design and <i>standard reference design</i> , and shall be established such that no smaller number of unmet heating load hours and no larger heating capacity safety factors are provided than in the proposed design. Weather conditions used in sizing runs to determine <i>standard reference design</i> equipment capacities may be based either on hourly historical weather files containing typical peak conditions or on design days developed using 99.6% heating design temperatures and 1% drybulb and 1% wet-bulb cooling design temperatures.	As proposed
Cooling systems	Fuel type: Same as proposed design Equipment type ^c : From Tables C407.5.1(2) and C407.5.1(3) Efficiency: From Tables C403.2.3(1),	As proposed As proposed As proposed
	C403.2.3(2) and C403.2.3(3) Capacity ^b : Sized proportionally to the capacities in the proposed design based on sizing runs, i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be the same for both the proposed design and <i>standard reference design</i> , and shall be established such that no smaller number of unmet cooling load hours and no larger cooling capacity safety factors are provided than in the proposed design.	As proposed
	Economizer ^d : Same as proposed, in accordance with Section C403.4.1. The high-limit shutoff shall be a dry-bulb switch with a setpoint as determined by Table C403.3.1.1.3(2).	As proposed
Energy recovery	Standard reference design systems shall be modeled where required in Section C403.2.6.	As proposed

Building Component Characteristics	Standard Reference Design	Proposed Design
Fan systems	Airflow rate: System design supply airflow rates for the <i>standard reference design</i> shall be based on a supply-air-to-room-air temperature difference of 20°F or the required ventilation air or makeup air, whichever is greater. If return or relief fans are specified in the proposed design, the <i>standard reference design</i> shall also be modeled with fans serving the same functions and sized for the <i>standard reference design</i> system supply fan air quantity less the minimum outdoor air, or 90% of the supply fan air quantity, whichever is larger.	As proposed
	Motor brake horsepower: System fan electrical power for supply, return, exhaust, and relief (excluding power to fan-powered VAV boxes) shall be calculated using the following formulas: For systems 8 and 10, Pfan = CFMS × 0.3 For all other systems, Pfan = bhp × 746/Fan Motor Efficiency Where: Pfan = Electric power to fan motor (watts) bhp = Brake horsepower of <i>standard reference design</i> fan motor from Table C403.2.10.1(1) – Option 2 Fan motor = The efficiency from Table C403.2.13 for the efficiency next motor size greater than the bhp using the enclosed motor at 1800 rpm CFMS = The <i>standard reference design</i> system maximum design supply fan airflow rate in cfm	As proposed
On-site renewable energy	No on-site renewable energy shall be modeled in the <i>standard reference design</i> .	As proposed. On-site renewable energy sources energy shall not be considered to be consumed energy and shall not be included in the proposed building performance.
Shading from adjacent structures/terrain	Same as proposed.	For the standard reference design and the proposed building, shading by permanent structures and terrain shall be taken into account for computing energy consumption whether or not these features are located on the building site. A permanent fixture is one that is likely to remain for the life of the proposed design.
Service water heating	Fuel type: Same as proposed Efficiency: From Table C404.2 Capacity: Same as proposed	As proposed As proposed

Building Component		
Characteristics	Standard Reference Design	Proposed Design
	Same as proposed	Demand: Service hot-water energy consumption shall be calculated explicitly based upon the volume of service hot water required and the entering makeup water and the leaving service hot water temperatures. Entering water temperatures shall be estimated based upon the location. Leaving temperatures shall be based upon the end-use requirements. Service water loads and usage shall be the same for both the standard reference design and the proposed design and shall be documented by the calculation procedures recommended by the manufacturer's specifications or generally accepted engineering methods.
	Where no service water hot water system exists or is specified in the proposed design, no service	As proposed
	hot water heating shall be modeled.	

^aWhere no heating system exists or has been specified, the heating system shall be modeled as fossil fuel. The system characteristics shall be identical in both the standard reference design and proposed design.

WAC 51-11C-407052 Table C407.5.1(2)--HVAC systems map.

Table C407.5.1(2)

HVAC Systems Map

		Standard Refe	rence Design HVAC	System Type ^c
Condenser Cooling Source ^a	Heating System Classification ^b	Single-Zone Residential System	Single-Zone Nonresidential System	All Other
	Electric resistance	System 5	System 5	System 1
Water/ground	Heat pump	System 6	System 6	System 6

^bThe ratio between the capacities used in the annual simulations and the capacities determined by sizing runs shall be the same for both the standard reference design and proposed design.

^cWhere no cooling system exists or no cooling system has been specified, the cooling system shall be modeled as an air-cooled single-zone system, one unit per thermal zone. The system characteristics shall be identical in both the standard reference design and proposed design. ^dReserved.

		Standard Reference Design HVAC System Type ^c		System Type ^c
Condenser Cooling Source ^a	Heating System Classification ^b	Single-Zone Residential System	Single-Zone Nonresidential System	All Other
	Fossil fuel	System 7	System 7	System 2
	Electric resistance	System 8	System 9	System 3
Air/none	Heat pump	System 8	System 9	System 3
	Fossil fuel	System 10	System 11	System 4

^aSelect "water/ground" if the proposed design system condenser is water or evaporatively cooled; select "air/none" if the condenser is air cooled. Closed-circuit dry coolers shall be considered air cooled. Systems utilizing district cooling shall be treated as if the condenser water type were "water." If no mechanical cooling is specified or the mechanical cooling system in the proposed design does not require heat rejection, the system shall be treated as if the condenser water type were "Air." For proposed designs with ground-source or groundwater-source heat pumps, the standard reference design HVAC system shall be water-source heat pump (System 6).

bSelect the path that corresponds to the proposed design heat source: Electric resistance, heat pump (including air source and water source), or fuel fired. Systems utilizing district heating (steam or hot water) and systems with no heating capability shall be treated as if the heating system type were "fossil fuel." For systems with mixed fuel heating sources, the system or systems that use the secondary heating source type (the one with the smallest total installed output capacity for the spaces served by the system) shall be modeled identically in the standard reference design and the primary heating source type shall be used to determine *standard reference design* HVAC system type.

Select the *standard reference design* HVAC system category: The system under "single-zone residential system" shall be selected if the HVAC system in the proposed design is a single-zone system and serves a residential space. The system under "single-zone nonresidential system" shall be selected if the HVAC system in the proposed design is a single-zone system and serves other than residential spaces. The system under "all other" shall be selected for all other cases.

NEW SECTION

WAC 51-11C-407053 Table C407.5.1(3) —Specifications for the standard reference design HVAC system description.

Table C407.5.1(3)
Specifications for the Standard Reference Design HVAC System
Descriptions

System No.	System Type	Fan Control	Cooling Type	Heating Type
1	Variable air volume with parallel fan- powered boxes ^a	VAV ^d	Chilled water ^e	Electric resistance
2	Variable air volume with reheat ^b	VAV ^d	Chilled water ^e	Hot water fossil fuel boiler ^f
3	Packaged variable air volume with parallel fan-powered boxes ^a	VAV ^d	Direct expansion ^c	Electric resistance
4	Packaged variable air volume with reheat ^b	VAV ^d	Direct expansion ^c	Hot water fossil fuel boiler
5	Two-pipe fan coil	Constant volume ⁱ	Chilled water ^e	Electric resistance
6	Water-source heat pump	Constant volume ⁱ	Direct expansion ^c	Electric heat pump and boiler ^g
7	Four-pipe fan coil	Constant volume ⁱ	Chilled water ^e	Hot water fossil fuel boiler ^f

System No.	System Type	Fan Control	Cooling Type	Heating Type
8	Packaged terminal heat pump	Constant volume ⁱ	Direct expansion ^c	Electric heat pump ^h
9	Packaged rooftop heat pump	Constant volume ⁱ	Direct expansion ^c	Electric heat pump ^h
10	Packaged terminal air conditioner	Constant volume ⁱ	Direct expansion	Hot water fossil fuel boiler
11	Packaged rooftop air conditioner	Constant volume ⁱ	Direct expansion	Fossil fuel furnace

For SI: 1 foot = 304.8 mm, 1 cfm/ft² = 0.0004719, 1 Btu/h = 0.293/W, $^{\circ}$ C = [($^{\circ}$ F) -32/1.8].

^aVAV with parallel boxes: Fans in parallel VAV fan-powered boxes shall be sized for 50 percent of the peak design flow rate and shall be modeled with 0.35 W/cfm fan power. Minimum volume setpoints for fan-powered boxes shall be equal to the minimum rate for the space required for ventilation consistent with Section C403.4.5, Exception 5. Supply air temperature setpoint shall be constant at the design condition.

^bVAV with reheat: Minimum volume setpoints for VAV reheat boxes shall be 0.4 cfm/ft² of floor area. Supply air temperature shall be reset based on zone demand from the design temperature difference to a 10°F temperature difference under minimum load conditions. Design airflow rates shall be sized for the reset supply air temperature, i.e., a 10°F temperature difference.

^cDirect expansion: The fuel type for the cooling system shall match that of the cooling system in the proposed design.

^dVAV: When the proposed design system has a supply, return or relief fan motor horsepower (hp) requiring variable flow controls as required by Section C403.2.12, the corresponding fan in the VAV system of the standard reference design shall be modeled assuming a variable speed drive. For smaller fans, a forward-curved centrifugal fan with inlet vanes shall be modeled. If the proposed design's system has a direct digital control system at the zone level, static pressure setpoint reset based on zone requirements in accordance with Section C403.4.2 shall be modeled.

eChilled water: For systems using purchased chilled water, the chillers are not explicitly modeled. Otherwise, the standard reference design's chiller plant shall be modeled with chillers having the number as indicated in Table C407.5.1(4) as a function of standard reference building chiller plant load and type as indicated in Table C407.5.1(5) as a function of individual chiller load. Where chiller fuel source is mixed, the system in the standard reference design shall have chillers with the same fuel types and with capacities having the same proportional capacity as the proposed design's chillers for each fuel type. Chilled water supply temperature shall be modeled at 44°F design supply temperature and 56°F return temperature. Piping losses shall not be modeled in either building model. Chilled water supply water temperature shall be reset in accordance with Section C403.4.3.4. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no chilled water pumps, the standard reference design pump power shall be 22 W/gpm (equal to a pump operating against a 75-foot head, 65-percent combined impeller and motor efficiency). The chilled water system shall be modeled as primary-only variable flow with flow maintained at the design rate through each chiller using a bypass. Chilled water pumps shall be modeled as riding the pump curve or with variable-speed drives when required in Section C403.4.3.4. The heat rejection device shall be an axial fan cooling tower with variable speed fans if required in Section C403.4.4 or Section C403.2.12. Condenser water design supply temperature shall be 85°F or 10°F approach to design wet-bulb temperature, whichever is lower, with a design temperature rise of 10°F. The tower shall be controlled to maintain a 70°F leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no condenser water pumps, the standard reference design pump power shall be 19 W/gpm (equal to a pump operating against a 60-foot head, 60-percent combined impeller and motor efficiency). Each chiller shall be modeled with separate condenser water and chilled water pumps interlocked to operate with the associated chiller.

Fossil fuel boiler: For systems using purchased hot water or steam, the boilers are not explicitly modeled. Otherwise, the boiler plant shall use the same fuel as the proposed design and shall be natural draft. The standard reference design boiler plant shall be modeled with a single boiler if the standard reference design plant load is 600,000 Btu/h and less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers shall be staged as required by the load. Hot water supply temperature shall be modeled at 180°F design supply temperature and 130°F return temperature. Piping losses shall not be modeled in either building model. Hot water supply water temperature shall be reset in accordance with Section C403.4.3.4. Pump system power for each pumping system shall be the same as the proposed design; if the proposed design has no hot water pumps, the standard reference design pump power shall be 19 W/gpm (equal to a pump operating against a 60-foot head, 60-percent combined impeller and motor efficiency). The hot water system shall be modeled as primary only with continuous variable flow. Hot water pumps shall be modeled as riding the pump curve or with variable speed drives when required by Section C403.4.3.4.

Electric heat pump and boiler: Water-source heat pumps shall be connected to a common heat pump water loop controlled to maintain temperatures between 60°F and 90°F. Heat rejection from the loop shall be provided by an axial fan closed-circuit evaporative fluid cooler with variable speed fans if required in Section C403.4.2 or Section C403.2.12. Heat addition to the loop shall be provided by a boiler that uses the same fuel as the proposed design and shall be natural draft. If no boilers exist in the proposed design, the standard reference building boilers shall be fossil fuel. The standard reference design boiler plant shall be modeled with a single boiler if the standard reference design plant load is 600,000 Btu/h or less and with two equally sized boilers for plant capacities exceeding 600,000 Btu/h. Boilers shall be staged as required by the load. Piping losses shall not be modeled in either building model. Pump system power shall be the same as the proposed design; if the proposed design has no pumps, the standard reference design pump power shall be 22 W/gpm, which is equal to a pump operating against a 75-foot head, with a 65-percent combined impeller and motor efficiency. Loop flow shall be variable with flow shutoff at each heat pump when its compressor cycles off as required by Section C403.4.3.3. Loop pumps shall be modeled as riding the

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pump curve or with variable speed drives when required by Section C403.4.3.4.

^hElectric heat pump: Electric air-source heat pumps shall be modeled with electric auxiliary heat. The system shall be controlled with a multistage space thermostat and an outdoor air thermostat wired to energize auxiliary heat only on the last thermostat stage and when outdoor air temperature is less than 40°F. In heating operation the system shall be controlled to operate the heat pump as the first stage of heating, before energizing the electric auxiliary heat, down to a minimum outdoor air temperature of 35°F for System No. 8 or 17°F for System No. 9. If the Proposed Design utilizes the same system type as the Standard Design (PTHP or PSZ-HP), the Proposed Design shall be modeled with the same minimum outdoor air temperature for heat pump operation as the Standard Design. For temperatures below the stated minimum outdoor air temperatures, the electric auxiliary heat shall be controlled to provide the full heating load.

*Constant volume: Fans shall be controlled in the same manner as in the proposed design; i.e., fan operation whenever the space is occupied or fan operation cycled on calls for heating and cooling. If the fan is modeled as cycling and the fan energy is included in the energy efficiency rating of the equipment, fan energy shall not be modeled explicitly.

NEW SECTION

WAC 51-11C-407054 Table C407.5.1(4)--Number of chillers. Table C407.5.1(4) Number of Chillers

Total Chiller Plant Capacity	Number of Chillers
≤ 300 tons	1
> 300 tons, < 600 tons	2, sized equally
≥ 600 tons	2 minimum, with chillers added so that no chiller is larger than 800 tons, all sized equally

For SI: 1 ton = 3517 W.

NEW SECTION

WAC 51-11C-407055 Table C407.5.1(5)--Water chiller types.

Table C407.5.1(5)

Water Chiller Types

Individual Chiller Plant Capacity	Electric-Chiller Type	Fossil Fuel Chiller Type
≤ 100 tons	Reciprocating	Single-effect absorption, direct fired
> 100 tons, < 300 tons	Screw	Double-effect absorption, direct fired

Individual Chiller Plant Capacity	Electric-Chiller Type	Fossil Fuel Chiller Type
≥ 300 tons	Centrifugal	Double-effect
		absorption, direct
		fired

For SI: 1 ton = 3517 W.

NEW SECTION

WAC 51-11C-40706 Section C407.6--Calculation software tool.

- **C407.6 Calculation software tools.** Calculation procedures used to comply with this section shall be software tools capable of calculating the annual energy consumption of all building elements that differ between the *standard reference design* and the *proposed design* and shall include the following capabilities.
 - 1. Building operation for a full calendar year (8,760 hours).
- 2. Climate data for a full calendar year (8,760 hours) and shall reflect approved coincident hourly data for temperature, solar radiation, humidity and wind speed for the building location.
 - 3. Ten or more thermal zones.
 - 4. Thermal mass effects.
- 5. Hourly variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads.
 - 6. Part-load performance curves for mechanical equipment.
- 7. Capacity and efficiency correction curves for mechanical heating and cooling equipment.
- 8. Printed code official inspection checklist listing each of the proposed design component characteristics from Table C407.5.1(1) determined by the analysis to provide compliance, along with their respective performance ratings (e.g., R-value, U-factor, SHGC, HSPF, AFUE, SEER, EF, etc.).
 - 9. Air-side economizers with integrated control.
- 10. Standard reference design characteristics specified in Table C407.5.1(1).
- **C407.6.1 Specific approval.** Performance analysis tools meeting the applicable subsections of Section C407 and tested according to ASHRAE Standard 140 shall be permitted to be approved. Tools are permitted to be approved based on meeting a specified threshold for a jurisdiction. The code official shall be permitted to approve tools for a specified application or limited scope.
- C407.6.2 Input values. Where calculations require input values not specified by Sections C402, C403, C404 and C405, those input values

shall be taken from an approved source.

- C407.6.3 Exceptional calculation methods. When the simulation program does not model a design, material, or device of the proposed design, an Exceptional Calculation Method shall be used if approved by the building official. If there are multiple designs, materials, or devices that the simulation program does not model, each shall be calculated separately and Exceptional Savings determined for each. At no time shall the total Exceptional Savings constitute more than half of the difference between the baseline building performance and the proposed building performance. All applications for approval of an exceptional method shall include:
- 1. Step-by-step documentation of the Exceptional Calculation Method performed detailed enough to reproduce the results;
- 2. Copies of all spreadsheets used to perform the calculations;
- 3. A sensitivity analysis of *energy* consumption when each of the input parameters is varied from half to double the value assumed;
- 4. The calculations shall be performed on a time step basis consistent with the *simulation program* used; and
- 5. The *Performance Rating* calculated with and without the Exceptional Calculation Method.

NEW SECTION

WAC 51-11C-40800 Section C408--System commissioning.

NEW SECTION

WAC 51-11C-40801 Section C408.1--General.

C408.1 General. This section covers the commissioning of the building mechanical systems in Section C403, service water heating systems in Section C404, electrical power and lighting systems in Section C405 and energy metering in Section C409. Prior to passing the final mechanical and electrical inspections or obtaining a certificate of occupancy, the *registered design professional* or approved agency shall provide evidence of systems *commissioning* and completion in accordance with the provisions of this section.

Copies of all documentation shall be given to the owner and made available to the $code\ official$ upon request in accordance with Sections C408.1.2 and C408.1.3.

- **C408.1.1 Commissioning plan.** A commissioning plan shall be developed by a registered design professional or approved agency and shall include the following items:
- 1. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.
 - 2. Roles and responsibilities of the commissioning team.
- 3. A schedule of activities including systems testing and balancing, functional testing, and supporting documentation.
- 4. A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed.
 - 5. Functions to be tested.
 - 6. Conditions under which the test will be performed.
 - 7. Measurable criteria for performance.
- **C408.1.2 Preliminary commissioning report.** A preliminary report of commissioning test procedures and results shall be completed and certified by the *registered design professional* or *approved agency* and provided to the building owner. The report shall be identified as "Preliminary Commissioning Report" and shall identify:
- 1. Itemization of deficiencies found during testing required by this section that have not been corrected at the time of report preparation.
- 2. Deferred tests that cannot be performed at the time of report preparation because of climatic conditions, with anticipated date of completion.
- 3. Climatic conditions required for performance of the deferred tests.
 - 4. Record of progress and completion of operator training.
- C408.1.2.1 Acceptance of report. Buildings, or portions thereof, shall not pass the final mechanical and electrical inspections or obtain a certificate of occupancy, until such time as the code official has received a letter of transmittal from the building owner acknowledging that the building owner has received the Preliminary Commissioning Report. Completion of the Commissioning Compliance Checklist (Figure C408.1.2.1) is deemed to satisfy this requirement.
- **C408.1.2.2 Copy of report.** The *code official* shall be permitted to require that a copy of the Preliminary Commissioning Report be made available for review by the *code official*.
- **C408.1.3 Documentation requirements.** The construction documents shall specify that the documents described in this section be provided to the building owner within 90 days of the date of receipt of the certificate of occupancy.
- **C408.1.3.1 Record documents.** Construction documents shall be updated to convey a record of the alterations to the original design. Such updates shall include updated mechanical, electrical and control drawings red-lined, or redrawn if specified, that show all changes to size, type and locations of components, equipment and assemblies.

- **C408.1.3.2 Manuals.** An operating and maintenance manual shall be provided and include all of the following:
- 1. Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance.
- 2. Manufacturer's operation manuals and maintenance manuals for each piece of equipment requiring maintenance, except equipment not furnished as part of the project. Required routine maintenance actions shall be clearly identified.
 - 3. Name and address of at least one service agency.
- 4. Controls system maintenance and calibration information, including wiring diagrams, schematics, record documents, and control sequence descriptions. Desired or field-determined setpoints shall be permanently recorded on control drawings at control devices or, for digital control systems, in system programming instructions.
- 5. A narrative of how each system is intended to operate, including recommended setpoints. Sequence of operation is not acceptable for this requirement.
- **C408.1.3.3 System balancing report.** A written report describing the activities and measurements completed in accordance with Section C408.2.2.
- **C408.1.3.4 Final commissioning report.** A report of test procedures and results identified as "Final Commissioning Report" shall be delivered to the building owner and shall include:
 - 1. Results of functional performance tests.
- 2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
- 3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.

EXCEPTION: Deferred tests which cannot be performed at the time of report preparation due to climatic conditions.

- **C408.1.4 Systems operation training.** Training of the maintenance staff for equipment included in the manuals required by Section C408.1.3.2 shall include at a minimum:
 - 1. Review of systems documentation.
- 2. Hands-on demonstration of all normal maintenance procedures, normal operating modes, and all emergency shutdown and start-up procedures.
 - 3. Training completion report.

NEW SECTION

WAC 51-11C-408012 Figure C408.1.2.1--Commissioning compliance checklist.

Figure C408.1.2.1

Commissioning Compliance Checklist

	Project Name:	
Project Information	Project Address:	
	Commissioning Authority:	
Commissioning Plan	☐ Commissioning Plan was used during construction and included items below	
(Section 408.1.1)	A narrative description of activities and the personnel intended to accomplish each one	
(,	Measurable criteria for performance	
	Functions to be tested	
Systems Balancing	☐ Systems Balancing has been completed	
(Section C408.2.2)	 Air and Hydronic systems are proportionately balanced in a manner to first minimize throttling losses. 	
	Test ports are provided on each pump for measuring pressure across the pump.	
Functional Testing	☐ HVAC Systems Equipment Testing has been completed (Section C408.2.3.1)	
(Section C408.2.3, C408.3.1, C408.4.1, C408.4.1.3 and C408.5.1)	HVAC equipment has been tested to demonstrate the installation and operation of components, systems and system-to-system interfacing relationships in accordance with approved plans and specifications	
	□ HVAC Controls Functional Testing has been completed (Section C408.2.3.2)	
	HVAC controls have been tested to ensure that control devices are calibrated, adjusted and operate properly. Sequences of operation have been functionally tested to ensure they operate in accordance with approved plans and specifications	
	☐ Economizers Functional Testing has been completed (Section C408.2.3.3)	
	Economizers operate in accordance with manufacturer's specifications	
	☐ Lighting Controls Functional Testing has been completed (Section C408.3.1)	
	Lighting controls have been tested to ensure that control devices, components, equipment, and systems are calibrated, adjusted and operate in accordance with approved plans and specifications	
	☐ Service Water Heating System Functional Testing has been completed (Section C408.4.1)	
	Service water heating equipment has been tested to ensure that control devices, components, equipment, and systems are calibrated, adjusted and operate in accordance with approved plans and specifications	
	□ Pool and Spa Functional Testing has been completed (Section C408.4.1.3)	
	Pools and spas have been tested to ensure that service water heating equipment, time switches and heat recovery equipment are calibrated, adjusted and operate in accordance with approved plans and specifications	
	☐ Metering System Functional Testing has been completed (Section C408.5.1)	
	Energy source meters, energy end-use meters, the energy metering data acquisition system and required display are calibrated adjusted and operate in accordance with approved plans and specifications	
Supporting Documents	☐ Manuals, record documents and training have been completed or are scheduled	
(Section 408.1.3.2)	System documentation has been provided to the owner or scheduled date:	
(5000001 100.1.5.2)	Record documents have been submitted to owner or scheduled date:	
	Training has been completed or scheduled date:	
	<u> </u>	
Commissioning Report	☐ Preliminary Commissioning Report submitted to Owner and includes items below	
(Section C408.1.2)	 Deficiencies found during testing required by this section which have not been corrected at the time of report preparation 	
	Deferred tests, which cannot be performed at the time of report preparation due to climatic deficience.	
	conditions	

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Certification	I hereby certify that all requirements for Commissionir the Washington State Energy Code, including all items	Z I
	Building Owner or Owner's Representative	Date

- WAC 51-11C-40802 Section C408.2--Mechanical systems commissioning and completion requirements.
- C408.2 Mechanical systems commissioning and completion requirements. Mechanical equipment and controls shall comply with Section C408.2.

Construction document notes shall clearly indicate provisions for *commissioning* and completion requirements in accordance with this section and are permitted to refer to specifications for further requirements. Exception: Systems which (a) qualify as simple systems using the criteria in Section C403.3, (b) are not required to have an economizer per Section C403.3.1, and (c) where the building total mechanical equipment capacity is less than 480,000 Btu/h (140,690 W) cooling capacity and 600,000 Btu/h (175,860 W) heating capacity.

C408.2.1 Reserved.

- **C408.2.2 Systems adjusting and balancing.** HVAC systems shall be balanced in accordance with generally accepted engineering standards. Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the product specifications. Test and balance activities shall include air system and hydronic system balancing.
- **C408.2.2.1 Air systems balancing.** Each supply air outlet and zone terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the *International Mechanical Code*. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 10 hp (18.6 kW) and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power of greater than 1 hp (0.74 kW), fan speed shall be adjusted to meet design flow conditions.

EXCEPTION: Fans with fan motors of 1 hp (0.74 kW) or less.

C408.2.2.2 Hydronic systems balancing. Individual hydronic heating and cooling coils shall be equipped with means for balancing and measuring flow. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have either the capability to measure pressure across the pump, or test ports at

each side of each pump.

EXCEPTIONS:

- 1. Pumps with pump motors of 5 hp (3.7 kW) or less.
- 2. Where throttling results in no greater than five percent of the nameplate horsepower draw above that required if the impeller were trimmed.
- **C408.2.3 Functional performance testing.** Functional performance testing specified in Sections C408.2.3.1 through C408.2.3.3 shall be conducted. Written procedures which clearly describe the individual systematic test procedures, the expected systems' response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion shall be followed. At a minimum, testing shall affirm operation during actual or simulated winter and summer design conditions and during full outside air conditions.
- **C408.2.3.1 Equipment.** Equipment functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing relationships in accordance with approved plans and specifications such that operation, function, and maintenance serviceability for each of the commissioned systems is confirmed. Testing shall include all modes and sequence of operation, including under full-load, part-load and the following emergency conditions:
 - 1. All modes as described in the sequence of operation;
 - 2. Redundant or automatic back-up mode;
 - 3. Performance of alarms; and
- 4. Mode of operation upon a loss of power and restoration of power.
- **C408.2.3.2 Controls.** HVAC control systems shall be tested to document that control devices, components, equipment, and systems are calibrated, adjusted and operate in accordance with approved plans and specifications. Sequences of operation shall be functionally tested to document they operate in accordance with approved plans and specifications.
- **C408.2.3.3 Economizers.** Air economizers shall undergo a functional test to determine that they operate in accordance with manufacturer's specifications.

NEW SECTION

- WAC 51-11C-40803 Section C408.3--Lighting system functional testing.
- **C408.3 Lighting system functional testing.** Controls for automatic lighting systems shall comply with Section C408.3.1.
- **C408.3.1 Functional testing.** Testing shall ensure that control hardware and software are calibrated, adjusted, programmed and in proper working condition in accordance with the construction

documents and manufacturer's installation instructions. Written procedures which clearly describe the individual systematic test procedures, the expected systems' response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion shall be followed. At a minimum, testing shall affirm operation during normally occupied daylight conditions. The construction documents shall state the party who will conduct the required functional testing.

Where occupant sensors, time switches, programmable schedule controls, photosensors or daylighting controls are installed, the following procedures shall be performed:

- 1. Confirm that the placement, sensitivity and time-out adjustments for occupant sensors yield acceptable performance.
- 2. Confirm that the time switches and programmable schedule controls are programmed to turn the lights off.
- 3. Confirm that the placement and sensitivity adjustments for photosensor controls reduce electric light based on the amount of usable daylight in the space as specified.

NEW SECTION

WAC 51-11C-40804 Section C408.4--Service water heating systems commissioning and completion requirements.

C408.4 Service water heating systems commissioning and completion requirements. Service water heating equipment and controls shall comply with Section C408.4. Construction document notes shall clearly indicate provisions for *commissioning* and completion requirements in accordance with this section and are permitted to refer to specifications for further requirements.

EXCEPTION:

The following systems are exempt from the commissioning requirements:

1. Service water heating systems in buildings where the largest service water heating system capacity is less than 200,000 Btu/h (58,562 W) and where there are no pools or in-ground permanently installed spas.

- **C408.4.1 Functional performance testing.** Functional performance testing specified in Sections C408.4.1.1 through C408.4.1.3 shall be conducted. Written procedures which clearly describe the individual systematic test procedures, the expected systems' response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion shall be followed. At a minimum, testing shall affirm operation with the system under 50 percent water heating load.
- **C408.4.1.1 Equipment.** Equipment functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing relationships in accordance with approved plans and specifications such that operation, function, and maintenance serviceability for each of the commissioned systems is confirmed. Testing shall include all modes and sequence of operation, including under full-load, part-load and

the following emergency conditions:

- 1. Redundant or automatic back-up mode;
- 2. Performance of alarms; and
- 3. Mode of operation upon a loss of power and restoration of power.
- **C408.4.1.2 Controls.** Service water heating controls shall be tested to document that control devices, components, equipment, and systems are calibrated, adjusted and operate in accordance with approved plans and specifications. Sequences of operation shall be functionally tested to document they operate in accordance with approved plans and specifications.
- **C408.4.1.3 Pools and spas.** Service water heating equipment, time switches, and heat recovery equipment which serve pools and inground permanently installed spas shall undergo a functional test to determine that they operate in accordance with manufacturer's specifications.

NEW SECTION

- WAC 51-11C-40805 Section C408.5--Metering system commissioning.
- **C408.5 Metering system commissioning.** Energy metering systems required by Section C409 shall comply with Section C408.5 and be included in the commissioning process required by Section C408.1. Construction documents shall clearly indicate provisions for *commissioning* in accordance with Section C408 and are permitted to refer to specifications for further requirements.
- C408.5.1 Functional testing. Functional testing shall be conducted by following written procedures which clearly describe the individual systematic test procedures, the expected systems' response or acceptance criteria for each procedure, the actual response or findings, and any pertinent discussion. Functional testing shall document that energy source meters, energy end-use meters, the energy metering data acquisition system, and required energy consumption display are calibrated, adjusted and operate in accordance with approved plans and specifications. At a minimum, testing shall confirm that:
- 1. The metering system devices and components work properly under low and high load conditions.
- 2. The metered data is delivered in a format that is compatible with the data collection system.
- 3. The energy display is accessible to building operation and management personnel.
- 4. The energy display meets code requirements regarding views required in Section C409.4.3. The display shows energy data in identical units (e.g., kWh).

WAC 51-11C-40900 Section C409--Energy metering and energy consumption management.

NEW SECTION

WAC 51-11C-40901 Section C409.1--General.

C409.1 General. Buildings with a gross conditioned floor area over 50,000 square feet shall comply with Section C409. Buildings shall be equipped to measure, monitor, record and display energy consumption data for each energy source and end use category per the provisions of this section, to enable effective energy management.

EXCEPTIONS:

- 1. Tenant spaces within buildings if the tenant space has its own utility service and utility meters.
- 2. Buildings in which there is no gross conditioned floor area over 25,000 square feet, including building common area, that is served by its own utility services and meters.
- C409.1.1 Alternate metering methods. Where approved by the building official, energy use metering systems may differ from those required by this section, provided that they are permanently installed and that the source energy measurement, end use category energy measurement, data storage and data display have similar accuracy to and are at least as effective in communicating actionable energy use information to the building management and users, as those required by this section.
- **C409.1.2 Conversion factor.** Any threshold stated in kW shall include the equivalent BTU/h heating and cooling capacity of installed equipment at a conversion factor of 3,412 Btu per kW at 50 percent demand.

NEW SECTION

WAC 51-11C-40902 Section C409.2--Energy source metering.

C409.2 Energy source metering. Buildings shall have a meter at each energy source. For each energy supply source listed in Section C409.2.1 through C409.2.4, meters shall collect data for the whole building or for each separately metered portion of the

building where not exempted by the exception to Section C409.1.

EXCEPTIONS:

- 1. Energy source metering is not required where end use metering for an energy source accounts for all usage of that energy type within a building, and the data acquisition system accurately totals the energy delivered to the building or separately metered portion of the building.
- 2. Solid fuels such as coal, firewood or wood pellets that are delivered via mobile transportation do not require metering.
- **C409.2.1 Electrical energy.** This category shall include all electrical energy supplied to the building and its associated site, including site lighting, parking, recreational facilities, and other areas that serve the building and its occupants.
- **C409.2.2 Gas and liquid fuel supply energy.** This category shall include all natural gas, fuel oil, propane and other gas or liquid fuel energy supplied to the building and site.
- **C409.2.3 District energy.** This category shall include all net energy extracted from district steam systems, district chilled water loops, district hot water systems, or other energy sources serving multiple buildings.
- **C409.2.4 Site-generated renewable energy.** This category shall include all net energy generated from on-site solar, wind, geothermal, tidal or other natural sources.

NEW SECTION

WAC 51-11C-40903 Section C409.3--End-use metering.

C409.3 End-use metering. Meters shall be provided to collect energy use data for each end-use category listed in Sections C409.3.1 through C409.3.2. These meters shall collect data for the whole building or for each separately metered portion of the building where not exempted by the exception to Section C409.1. Multiple meters may be used for any end-use category, provided that the data acquisition system totals all of the energy used by that category.

EXCEPTIONS:

- 1. HVAC and water heating equipment serving only an individual dwelling unit does not require end-use metering.
 2. Separate metering is not required for fire pumps, stairwell pressurization fans or other life safety systems that operate only during testing or emergency.
- 3. End use metering is not required for individual tenant spaces not exceeding 2,500 square feet in floor area when a dedicated source meter meeting the requirements of Section C409.4.1 is provided for the tenant space.
- C409.3.1 HVAC system energy use. This category shall include all energy including electrical, gas, liquid fuel, district steam and district chilled water that is used by boilers, chillers, pumps, fans and other equipment used to provide space heating, space cooling, dehumidification and ventilation to the building, but not including energy that serves process loads, water heating or miscellaneous loads as defined in Section C409.3. Multiple HVAC energy sources, such as gas, electric and steam, are not required to be summed together.

EXCEPTIONS: 1. All 120 volt equipment.

- 2. 208/120 volt equipment in a building where the main service is 480/277 volt power.
- 3. Electrical energy fed through variable frequency drives that are connected to the energy metering data acquisition center.

C409.3.2 Water heating energy use. This category shall include all energy used for heating of domestic and service hot water, but not energy used for space heating.

EXCEPTION: Water heating energy use less than 50 kW does not require end-use metering.

NEW SECTION

WAC 51-11C-40904 Section C409.4--Measurement devices, data acquisition system and energy display.

- C409.4 Measurement devices, data acquisition system and energy display.
- **C409.4.1 Meters.** Meters and other measurement devices required by this section shall have local displays or be configured to automatically communicate energy data to a data acquisition system. Source meters may be any digital-type meters. Current sensors or flow meters are allowed for end use metering, provided that they have an accuracy of +/- 5%. All required metering systems and equipment shall provide at least hourly data that is fully integrated into the data acquisition and display system per the requirements of Section C409.
- **C409.4.2 Data acquisition system.** The data acquisition system shall store the data from the required meters and other sensing devices for a minimum of 36 months. For each energy supply and end use category required by C409.2 and C409.3, it shall provide realtime energy consumption data and logged data for any hour, day, month or year.
- C409.4.3 Energy display. For each building subject to Section C409.2 and C409.3, either a readily accessible and visible display, or a web page or other electronic document accessible to building management or to a third-party energy data analysis service shall be provided in the building accessible by building operation and management personnel. The display shall graphically provide the current energy consumption rate for each whole building energy source, plus each end use category, as well as the average and peak values for any day, week or year.
- **C409.4.4 Commissioning.** The entire system shall be commissioned in accordance with Section C408.5. Deficiencies found during testing shall be corrected and retested and the commissioning report shall be updated to confirm that the entire metering and data acquisition and display system is fully functional.

- WAC 51-11C-40905 Section C409.5--Metering for existing buildings.
- C409.5 Metering for existing buildings.
- C409.5.1 Existing buildings that were constructed subject to the requirements of this section. Where new or replacement systems or equipment are installed in an existing building that was constructed subject to the requirements of this section, metering shall be provided for such new or replacement systems or equipment so that their energy use is included in the corresponding end-use category defined in Section C409.2. This includes systems or equipment added in conjunction with additions or alterations to existing buildings.
- **C409.5.1.1 Small existing buildings.** Metering and data acquisition systems shall be provided for additions over 25,000 square feet in accordance with the requirements of sections C409.2 and C409.3.

NEW SECTION

WAC 51-11C-50000 Chapter 5 [CE]--Referenced standards. This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section 106.

AAMA	American Architectural Manufacturers Association	
	1827 Walden Office Square	
	Suite 550	
	Schaumburg, IL 60173-4268	
Standard reference number	Title	Referenced in code section number
AAMA/WDMA/CSA 101/I.S.2/A C44011	North American Fenestration Standard/Specifications for Windows,	
101/110/2/11 0 1 10 11	Doors and Unit Skylights	Table C402.4.3
AHAM	Association of Home Appliance Manufacturers	
	1111 19th Street, N.W., Suite 402	
	Washington, D.C. 20036	
Standard reference number	Title	Referenced in code section number
ANSI/AHAM RAC-1	Room Air Conditioners	
2008		Table C403.2.3(3)
AHRI	Air Conditioning, Heating, and Refrigeration Institute	

	4100 North Fairfax Drive, Suite 200	
	Arlington, VA 22203	
Standard reference number	Title	Referenced in code section number
ISO/AHRI/ASHRAE		
13256-1 (2005)	Water-source Heat Pumps - Testing and Rating for Performance - Part 1: Water- to-air and Brine-to-air Heat Pumps	 Table C403.2.3(2)
ISO/AHRI/ASHRAE		
13256-2 (1998)	Water-source Heat Pumps - Testing and Rating for Performance - Part 2: Water- to-water and Brine-to-water Heat Pumps	 Table C403.2.3(2)
210/24008	Unitary Air Conditioning and Air-source Heat Pump Equipment	 Table C403.2.3(1), Table C403.2.3(2)
310/38004	Standard for Packaged Terminal Air Conditioners and Heat Pumps	 Table C403.2.3(3)
340/3602007	Commercial and Industrial Unitary Airconditioning and Heat Pump Equipment	 Table C403.2.3(1), Table C403.2.3(2)
36509	Commercial and Industrial Unitary Airconditioning Condensing Units	 Table C403.2.3(1), Table C403.2.3(6)
39003	Performance Rating of Single Package Vertical Air Conditioners and Heat Pumps	 Table C403.2.3(3)
40001	Liquid to Liquid Heat Exchangers with Addendum 2	 Table C403.2.3(9)
44008	Room Fan Coil	 C403.2.8
46005	Performance Rating Remote Mechanical Draft Air-cooled Refrigerant Condensers	 Table C403.2.3(8)
550/59003	Water Chilling Packages Using the Vapor Compression Cyclewith Addenda	 C403.2.3.1, Table C403.2.3(7), Table C406.2(6)
56000	Absorption Water Chilling and Water- heating Packages	 Table C403.2.3(7)
116008	Performance Rating of Heat Pump Pool Heaters	 Table C404.2
AMCA	Air Movement and Control Association International	
	30 West University Drive	
	Arlington Heights, IL 60004-1806	
Standard reference number	Title	Referenced in code section number
500D10	Laboratory Methods for Testing Dampers for Rating	 C402.4.5.1, C402.4.5.2
ANSI	American National Standards Institute 25 West 43rd Street	
	Fourth Floor New York, NY 10036	
Standard reference	Title	Referenced in code
number		section number
ANSI/ASME A17.1- 2010	Safety code for elevators and escalators	 C405.12.1

Z21.10.3/CSA 4.304	Gas Water Heaters, Volume IIIStorage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating Tank and Instantaneous		Table C404.2
Z21.47/CSA 2.306	Gas-fired Central Furnaces		Table C403.2.3(4),
Z83.8/CSA 2.609	Gos Unit Hasters Gos Books and Hasters		Table C406.2(4)
Z63.6/C5A 2.009	Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters and Gas-fired Duct		Table C403.2.3(4),
	Furnaces		Table C406.2(4)
ASHRAE	American Society of Heating, Refrigerating Conditioning Engineers, Inc.	and Air-	
	1791 Tullie Circle, N.E.		
	Atlanta, GA 30329-2305		
Standard reference number	Title		Referenced in code section number
ANSI/ASHRAE/ACCA			
Standard 127-2007	Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners		C403.4.1
Standard 1832007	Peak Cooling and Heating Load Calculations in Buildings, Except Low- rise Residential Buildings		C403.2.1
ASHRAE2004	ASHRAE HVAC Systems and Equipment Handbook2004		C403.2.1
ISO/AHRI/ASHRAE			
13256-1 (2005)	Water-source Heat PumpsTesting and Rating for Performance Part 1: Water- to-air and Brine-to-air Heat Pumps		Table C403.2.3(2)
ISO/AHRI/ASHRAE	1		` ,
13256-2 (1998)	Water-source Heat PumpsTesting and Rating for PerformancePart 2: Water-to- water and Brine-to-water Heat Pumps		Table C403.2.3(2)
90.12010	Energy Standard for Buildings Except Low-rise Residential Buildings (ANSI/ASHRAE/IESNA 90.12010)		C401.2, C401.2.1, C402.1.1, Table C402.1.2, Table C402.2, Table C407.6.1
11988 (RA 2004)	Air Lagkaga Parformana for Datashad		Table C407.6.1
11300 (NA 2004)	Air Leakage Performance for Detached Single-family Residential Buildings		Table C405.5.2(1)
1402010	Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs		C407.6.1
1462006	Testing and Rating Pool Heaters		Table C404.2
ASTM	ASTM International		14010 € 104.2
~	100 Barr Harbor Drive		
	West Conshohocken, PA		
	19428-2859		
Standard reference number	Title		Referenced in code section number

C 9008	Specification for Load-bearing Concrete Masonry Units	 Table C402.2
C 137104	Standard Test Method for Determination of Emittance of Materials Near Room	
C 154904	Temperature Using Portable Emissometers Standard Test Method for Determination of Solar Reflectance Near Ambient	 Table C402.2.1.1
	Temperature Using A Portable Solar Reflectometer	 Table C405.2.1.1
D 100307e1	Standard Test Method for Haze and Luminous Transmittance of Transparent	
	Plastics	 C402.3.2.2
E 28304	Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen	 Table C402.2.1.1, C402.4.1.2.2, Table C402.4.3, C402.4.4, C402.4.8
E 40871 (2002)	Test Methods for Total Normal Emittance	
(2002)	of Surfaces Using Inspection-meter Techniques	 Table C402.2.1.1
E 77903	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization	 C402.4.1.2.3
E 90396	Standard Test Method Solar Absorptance, Reflectance and Transmittance of Materials Using Integrating Spheres (Withdrawn 2005)	 Table C402.2.1.1
E 167705	Standard Specification for an Air-retarder (AR) Material or System for Low-rise Framed Building Walls	 C402.4.1.2.2
E 191897	Standard Test Method for Measuring Solar Reflectance of Horizontal or Low- sloped Surfaces in the Field	 Table C402.2.1.1
E 1980(2001)	Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low- sloped Opaque Surfaces	 Table C402.2.1.1
E 217803	Standard Test Method for Air Permanence of Building Materials	 C402.4.1.2.1
E 235705	Standard Test Method for Determining Air Leakage of Air Barrier Assemblies	 C404.1.2.2
CSA	Canadian Standards Association	
	5060 Spectrum Way	
	Mississauga, Ontario, Canada L4W 5N6	
Standard reference number	Title	Referenced in code section number
AAMA/WDMA/CSA 101/I.S.2/A44011	North American Fenestration Standard/Specification for Windows, Doors and Unit Skylights	 R402.4.3
CTI	Cooling Technology Institute	
	2611 FM 1960 West, Suite A-101	
	Houston, TX 77068	
Standard reference number	Title	Referenced in code section number

ATC 105 (00)	Acceptance Test Code for Water Cooling Tower	 Table C403.2.3(8)
STD 20109	Standard for Certification of Water Cooling Towers Thermal Performances	 Table C403.2.3(8)
DASMA	Door and Access Systems Manufacturers Association 1300 Sumner Avenue	
Standard reference	Cleveland, OH 44115-2851 Title	Referenced in code section number
10592 (R2004)	Test Method for Thermal Transmittance and Air Infiltration of Garage Doors	 Table C402.4.3
DOE	U.S. Department of Energy c/o Superintendent of Documents U.S. Government Printing Office Washington, D.C. 20402-9325	
Standard reference number	Title	Referenced in code section number
10 C.F.R., Part 4301998	Energy Conservation Program for Consumer Products:	
	Test Procedures and Certification and Enforcement Requirement for Plumbing Products; and Certification and Enforcement Requirements for Residential Appliances; Final Rule	 Table C403.2.3(4), Table C403.2.3(5), Table C404.2, Table C406.2(4), Table C406.2(5)
10 C.F.R., Part 430, Subpart B, Appendix N 1998	Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers	
		 C202
10 C.F.R., Part 4312004	Energy Efficiency Program for Certain Commercial and Industrial Equipment: Test Procedures and Efficiency Standards; Final Rules	 Table C403.2.3(5), Table C406.2(5)
NAECA 87(88)	National Appliance Energy Conservation Act 1987 [(Public Law 100-12 (with Amendments of 1988-P.L. 100-357)]	 Tables C403.2.3 (1), (2), (4)
IAPMO	International Association of Plumbing and Mechanical Officials 4755 E. Philadelphia Street	
	Ontario, CA 91761	
Standard reference number	Title	Referenced in code section number
UPC2012	Uniform Plumbing Code	 C201.3
ICC	International Code Council, Inc. 500 New Jersey Avenue, N.W., 6th Floor Washington, DC 20001	
Standard reference number	Title	Referenced in code section number

IBC12	International Building Code	 C201.3, C303.2, C402.4.4
IFC12	International Fire Code	 C201.3
IFGC12	International Fuel Gas Code	 C201.3
IMC12	International Mechanical Code	 C403.2.5, C403.2.5.1, C403.2.6, C403.2.7, C403.2.7.1, C403.2.7.1.1, C403.2.7.1.2, C403.2.7.1.3, C403.4.5, C408.2.2.1
IESNA	Illuminating Engineering Society of North America	
	120 Wall Street, 17th Floor	
	New York, NY 10005-4001	
Standard reference number	Title	Referenced in code section number
ANSI/ASHRAE/IESNA 90.12010	Energy Standard for Buildings Except Low-rise Residential Buildings	 C401.2, C401.2.1, C402.1.1, Table C402.1.2, Table C402.2, Table C407.6.1
ISO	International Organization for Standardization	
	1, rue de Varembe, Case postale 56, CH-1211	
	Geneva, Switzerland	
Standard reference number	Title	Referenced in code section number
ISO/AHRI/ASHRAE 13256-1 (2005)	Water-source Heat PumpsTesting and Rating for PerformancePart 1: Water-to- air and Brine-to-air Heat Pumps	 C403.2.3(2)
ISO/AHRI/ASHRAE 13256-2 (1998)	Water-Source Heat PumpsTesting and Rating for PerformancePart 2: Water-to- water and Brine-to-water Heat Pumps	 C403.2.3(2)
NEMA	National Electric Manufacturers Association 1300 North 17th Street Suite 1752	
	Rosslyn, VA 22209	
Standard reference number	Title	 Referenced in code section number
TP-1-2002	Guide for Determining Energy Efficiency for Distribution Transformers	 C405.9
NFRC	National Fenestration Rating Council, Inc. 6305 Ivy Lane, Suite 140 Greenbelt, MD 20770	
Standard reference number	Title	Referenced in code section number
1002010	Procedure for Determining Fenestration Product U-factors	 C303.1.2, C402.2.1

2002010	Procedure for Determining Fenestration Product Solar Heat Gain Coefficients and Visible Transmittance at Normal Incidence		C303.1.3, C402.3.1.1
4002010	Procedure for Determining Fenestration Product Air Leakage		Table C402.4.3
SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc.		
	4021 Lafayette Center Drive		
	Chantilly, VA 20151-1209		
Standard reference number	Title		Referenced in code section number
SMACNA85	HVAC Air Duct Leakage Test Manual		C403.2.7.1.3
UL	Underwriters Laboratories		
	333 Pfingsten Road		
	Northbrook, IL 60062-2096		
Standard reference	Title		Referenced in code
number			section number
72706	Oil-fired Central Furnaceswith Revisions through April 2010		Table C403.2.3(4), Table C406.2(4)
73195	Oil-fired Unit Heaterswith Revisions through April 2010		Table C403.2.3(4), Table C406.2(4)
US-FTC	United States-Federal Trade Commission		
	600 Pennsylvania Avenue N.W.		
	Washington, DC 20580		
Standard reference number	Title		Referenced in code section number
C.F.R. Title 16	R-value Rule		
(May 31, 2005)			C303.1.4
WDMA	Window and Door Manufacturers Association	on	
	1400 East Touhy Avenue, Suite 470		
	Des Plaines, IL 60018		
Standard reference number	Title		Referenced in code section number
AAMA/WDMA/CSA	North American Fenestration		
101/I.S.2/A44011	Standard/Specification for Windows,		T. 1.1. C.402.4.2
	Doors and Unit Skylights		Table C402.4.3

WAC 51-11C-60000 Appendix A--Default heal loss coefficients.

WAC 51-11C-61010 Section A101--General.

NEW SECTION

WAC 51-11C-61011 Section A101.1--Scope.

A101.1 Scope. The following defaults shall apply to Chapter 4 of both the (RE) and (CE) sections of the IECC. This chapter includes tables of seasonal average heat loss coefficients for specified nominal insulation.

NEW SECTION

WAC 51-11C-61012 Section A101.2--Description.

A101.2 Description. These coefficients were developed primarily from data and procedures from the ASHRAE Fundamentals Handbook.

Coefficients not contained in this chapter may be computed using the procedures listed in this reference if the assumptions in the following sections are used, along with data from the sources referenced above.

NEW SECTION

WAC 51-11C-61013 Section A101.3--Air films.

A101.3 Air films. Default R-values used for air films shall be as follows:

R-Value	Condition
0.17	All exterior surfaces
0.61	Interior horizontal surfaces, heat flow up
0.92	Interior horizontal surfaces, heat flow down
0.68	Interior vertical surfaces

WAC 51-11C-61014 Section A101.4--Compression of insulation.

A101.4 Compression of insulation. Insulation which is compressed shall be rated in accordance with Table A101.4 or reduction in value may be calculated in accordance with the procedures in the ASHRAE Fundamentals Handbook.

Table A101.4
R-value of Fiberglass Batts Compressed Within Various Depth
Cavities

	Insulation R-Values at Standard Thickness												
Rated R	2-Value	82	71	60	49	38	30	22	21	19	15	13	11
Standard T Incl		26.0	26.0 22.5 19.0 15.5 12 9.5 6.5 5.5 6 3.5 3.5					3.5					
Nominal Lumber Sizes, Inches	Actual Depth of Cavity, Inches		Insulation R-Values when Installed in a Confined Cavity										
Truss	26.0	82		-									
Truss	22.5		71	-									
Truss	19.0			60									
Truss	15.5	-1	1	1	49					-	-		
Truss	12.0			-		38							
2 x 12	11.25			-		37							
2 x 10	9.25					32	30						
2 x 8	7.25	-	-	-		27	26	22	21	19	-		
2 x 6	5.5						21	20	21	18			
2 x 4	3.5							14		13	15	13	11
	2.5											9.8	
	1.5											6.3	6.0

NEW SECTION

WAC 51-11C-61015 Section A101.5--Building materials.

A101.5 Building materials. Default R-values used for building materials shall be as shown in Table A101.5.

Table A101.5
Default R-values for Building Materials

Material	Nominal Size (in.)	Actual Size (in.)	R-Value (Heat Capacity ^c)
Air cavity (unventilated), between metal studs at 16 inches on center ^a	ı	ı	0.79

Material	Nominal Size (in.)	Actual Size (in.)	R-Value (Heat Capacity ^c)
Air cavity (unventilated), all other depths and framing materials ¹	-	-	0.91
Airfilm, exterior surfaces ^b	-	-	0.17
Airfilm, interior horizontal surfaces, heat flow up ^b	-	-	0.61
Airfilm, interior horizontal surfaces, heat flow down ^b	-	-	0.92
Airfilm, interior vertical surfaces ^b	-	-	0.68
Brick at R-0.12/in. (face brick, 75% solid/25% core area, 130 lbs/ft³)	4	3.5	0.32 (5.9)
Carpet and rubber pad	-	-	1.23
Concrete at R-0.0625/in., heavyweight (144 lbs/ft³)	-	2	0.13 (HC-4.8)
	-	4	0.25 (HC-9.6)
	-	6	0.38 (HC-14.4)
	-	8	0.50 (HC-19.2)
	-	10	0.63 (HC-24.0)
	-	12	0.75 (HC-28.8)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft³)	6	-	0.80 (HC-11.4)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft³)	6	-	0.51 (HC-13.2)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft³)	6	-	1.33 (HC-6.7)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft³)	6	-	0.82 (HC-9.0)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft³)	8	-	1.05 (HC-15.5)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft³)	8	-	0.69 (HC-17.9)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft³)	8	-	1.44 (HC-9.6)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft³)	8	-	0.98 (HC-12.0)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft³)	10	-	1.30 (HC-19.7)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft³)	10	-	0.87 (HC-22.6)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft³)	10	-	1.61 (HC-11.9)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft³)	10	-	1.11 (HC-14.8)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft³)	12	-	1.53 (HC-23.9)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft³)	12	-	1.06 (HC-27.2)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft³)	12	-	1.75 (HC-14.2)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft³)	12	-	1.23 (HC-17.5)
Flooring, wood subfloor	-	0.75	0.94
Gypsum board	-	0.5	0.45
	-	0.625	0.56
Metal deck	-	-	0
Roofing, built-up	-	0.375	0.33
Sheathing, vegetable fiber board, 0.78 in.	-	0.78	2.06
Soil at R-0.104/in.	-	12	1.25
Steel, mild		1	0.0031807
Stucco	-	0.75	0.08

^aThere is no credit for cavities that are open to outside air.

bAir films do not apply to air cavities within an assembly.

For heat capacity for concrete and concrete masonry materials with densities other than the values listed in Table A101.5, see Tables A3.1B and A3.1C in ASHRAE/IESNA Standard 90.1.

WAC 51-11C-61020 Section A102--Ceilings.

NEW SECTION

WAC 51-11C-61021 Section A102.1--General.

A102.1 General. Table A102.1 lists heat loss coefficients for the opaque portion of exterior ceilings below vented attics, vaulted ceilings and roof decks in units of Btu/h \bullet ft² \bullet °F of ceiling.

They are derived from procedures listed in the ASHRAE Fundamentals Handbook. Ceiling U-factors are modified for the buffering effect of the attic, assuming an indoor temperature of $65\,^{\circ}\mathrm{F}$ and an outdoor temperature of $45\,^{\circ}\mathrm{F}$.

A102.1.1 Metal framed ceilings. The nominal R-values in Table A103.3.6.2: Effective R-Values for Metal Framing and Cavity Only may be used for purposes of calculating metal framed ceiling section U-factors in lieu of the ASHRAE zone calculation method as provided in Chapter 27 of the ASHRAE Fundamentals Handbook.

Metal building roofs have a different construction and are addressed in Table A102.2.5.

NEW SECTION

WAC 51-11C-610211 Table A102.1--Default U-factors for ceilings.

Table A102.1
Default U-factors for Ceilings

	Standard Frame	Advanced Frame
Ceilings Below Vented Attics	•	-
Flat	Baf	fled
R-19	0.049	0.047
R-30	0.036	0.032
R-38	0.031	0.026
R-49	0.027	0.020
R-60	0.025	0.017
Scissors Truss		
R-30 (4/12 roof pitch)	0.043	0.031
R-38 (4/12 roof pitch)	0.040	0.025
R-49 (4/12 roof pitch)	0.038	0.020
R-30 (5/12 roof pitch)	0.039	0.032
R-38 (5/12 roof pitch)	0.035	0.026
R-49 (5/12 roof pitch)	0.032	0.020

			Standard Frame	Advanced Frame
Ceilings Belo	ow Vented Att	ics		
Vaulted Ceil	ings		16" O.C.	24" O.C.
Vented				
R-19 2x1	0 joist		0.049	0.048
R-30 2x1	2 joist		0.034	0.033
R-38 2x1	4 joist		0.027	0.027
Unvented	d			
R-30 2x1	0 joist		0.034	0.033
R-38 2x1	2 joist		0.029	0.027
R-21 + R	-21 2x12 joist		0.026	0.025
Roof Deck			4 x Beams	, 48" O.C.
R-12.5	2"	Rigid insulation	0.0	64
R-21.9	3.5"	Rigid insulation	0.0	40
R-37.5	6"	Rigid insulation	0.0	25
R-50	8"	Rigid insulation	0.0	19

WAC 51-11C-61022 Section A102.2--Component description.

A102.2 Component description. The four types of ceilings are characterized as follows:

A102.2.1 Ceilings below a vented attic. Attic insulation is assumed to be blown-in, loose-fill fiberglass with a K-value of 2.6 h \bullet ft² \bullet °F/Btu per inch. Full bag count for specified R-value is assumed in all cases. Ceiling dimensions for flat ceiling calculations are 45 by 30 feet, with a gabled roof having a 4/12 pitch. The attic is assumed to vent naturally at the rate of 3 air changes per hour through soffit and ridge vents. A void fraction of 0.002 is assumed for all attics with insulation baffles. Standard-framed, unbaffled attics assume a void fraction of 0.008.

Attic framing is either standard or advanced. Standard framing assumes tapering of insulation depth around the perimeter with resultant decrease in thermal resistance. An increased R-value is assumed in the center of the ceiling due to the effect of piling leftover insulation. Advanced framing assumes full and even depth of insulation extending to the outside edge of exterior walls. Advanced framing does not change from the default value.

U-factors for flat ceilings below vented attics with standard framing may be modified with the following table:

	U-Factor for Standard Framing				
Roof Pitch	R-30	R-38			
4/12	0.036	0.031			
5/12	0.035	0.030			
6/12	0.034	0.029			
7/12	0.034	0.029			

	U-Factor Standard Fra	
Roof Pitch	R-30	R-38
8/12	0.034	0.028
9/12	0.034	0.028
10/12	0.033	0.028
11/12	0.033	0.027
12/12	0.033	0.027

Vented scissors truss attics assume a ceiling pitch of 2/12 with a roof pitch of either 4/12 or 5/12. Unbaffled standard framed scissors truss attics are assumed to have a void fraction of 0.016.

- A102.2.2 Vaulted ceilings. Insulation is assumed to be fiberglass batts installed in roof joist cavities. In the vented case, at least 1.5 inches between the top of the batts and the underside of the roof sheathing is left open for ventilation in each cavity. A ventilation rate of 3.0 air changes per hour is assumed. In the unvented or dense pack case, the ceiling cavity is assumed to be fully packed with insulation, leaving no space for ventilation.
- **A102.2.3 Roof decks.** Rigid insulation is applied to the top of roof decking with no space left for ventilation. Roofing materials are attached directly on top of the insulation. Framing members are often left exposed on the interior side.
- **A102.2.4 Metal truss framing.** Overall system tested values for the roof/ceiling U_\circ for metal framed truss assemblies from approved laboratories shall be used, when such data is acceptable to the building official.

Alternatively, the U_{\circ} for roof/ceiling assemblies using metal truss framing may be obtained from Tables A102.2.4(1) through A102.2.4(5).

A102.2.5 Metal building roof. Table A102.2.5: The base assembly is a roof where the insulation is compressed when installed beneath metal roof panels attached to the steel structure (purlins). Additional assemblies include continuous insulation, uncompressed and uninterrupted by framing.

U-factors for metal building roofs shall be taken from Table A102.2.5, provided the average purlin spacing is at least 52 inches and the R-value of the thermal spacer block is greater than or equal to the thermal spacer block R-value indicated in Table A107.2.5 for the assembly. It is not acceptable to use the U-factors in Table A102.2.6 if additional insulated sheathing is not continuous.

- **A102.2.5.1 Single layer.** The rated R-value of insulation is for insulation installed perpendicular to and draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.
- A102.2.5.2 Double layer. The first rated R-value of insulation is

for insulation installed perpendicular to and draped over purlins. The second rated R-value of insulation is for unfaced insulation installed above the first layer and parallel to the purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.

- A102.2.5.3 Continuous insulation. For continuous insulation (e.g., insulation boards or blankets), it is assumed that the insulation is installed below the purlins and is uninterrupted by framing members. Insulation exposed to the conditioned space or semiheated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.
- **A102.2.5.4 Liner system (Ls).** A continuous membrane is installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. For multilayer installations, the last rated R-value of insulation is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.
- A102.2.5.5 Filled cavity. The first rated R-value of insulation is for faced insulation installed parallel to the purlins. The second rated R-value of insulation is for unfaced insulation installed above the first layer, parallel to and between the purlins and compressed when the metal roof panels are attached. The facer of the first layer of insulation is of sufficient width to be continuously sealed to the top flange of the purlins and to accommodate the full thickness of the second layer of insulation. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of the second layer of insulation being installed above it. A minimum R-5 (R-0.9) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly U-factor.
- A102.2.6 Roofs with insulation entirely above deck (uninterrupted by framing). Table A102.2.6: The base assembly is continuous insulation over a structural deck. Added insulation is continuous and uninterrupted by framing. For the insulation, the first column lists the R-value for continuous insulation with a uniform thickness; the second column lists the comparable area-weighted average R-value for continuous insulation provided that the insulation thickness is never less than R-5 (except at roof drains) and that the slope is no greater than 1/4 inch per foot.

WAC 51-11C-610221 Tables A102.2.4--Steel truss framed ceiling \mathbf{U}_{\circ} values.

Table A102.2.4(1)
Steel Truss Framed Ceiling U.

Cavity		Truss Span (ft)											
R-value	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.1075	0.0991	0.0928	0.0878	0.0839	0.0807	0.0780	0.0757	0.0737	0.0720	0.0706	0.0693	0.0681
30	0.0907	0.0823	0.0760	0.0710	0.0671	0.0638	0.0612	0.0589	0.0569	0.0552	0.0538	0.0525	0.0513
38	0.0844	0.0759	0.0696	0.0647	0.0607	0.0575	0.0548	0.0525	0.0506	0.0489	0.0474	0.0461	0.0449
49	0.0789	0.0704	0.0641	0.0592	0.0552	0.0520	0.0493	0.0470	0.0451	0.0434	0.0419	0.0406	0.0395

Table A102.2.4(2)
Steel Truss^a Framed Ceiling U_o with R-3 Sheathing

Cavity		Truss Span (ft)											
R-value	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0809	0.0763	0.0728	0.0701	0.0679	0.0661	0.0647	0.0634	0.0623	0.0614	0.0606	0.0599	0.0592
30	0.0641	0.0595	0.0560	0.0533	0.0511	0.0493	0.0478	0.0466	0.0455	0.0446	0.0438	0.0431	0.0424
38	0.0577	0.0531	0.0496	0.0469	0.0447	0.0430	0.0415	0.0402	0.0392	0.0382	0.0374	0.0367	0.0361
49	0.0523	0.0476	0.0441	0.0414	0.0393	0.0375	0.0360	0.0348	0.0337	0.0328	0.0319	0.0312	0.0306

Table A102.2.4(3) Steel Truss Framed Ceiling U with R-5 Sheathing

Cavity		Truss Span (ft)											
R-value	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0732	0.0697	0.0670	0.0649	0.0633	0.0619	0.0608	0.0598	0.0590	0.0583	0.0577	0.0571	0.0567
30	0.0564	0.0529	0.0502	0.0481	0.0465	0.0451	0.0440	0.0430	0.0422	0.0415	0.0409	0.0403	0.0399
38	0.0501	0.0465	0.0438	0.0418	0.0401	0.0388	0.0376	0.0367	0.0359	0.0351	0.0345	0.0340	0.0335
49	0.0446	0.0410	0.0384	0.0363	0.0346	0.0333	0.0322	0.0312	0.0304	0.0297	0.0291	0.0285	0.0280

Table A102.2.4(4)
Steel Truss Framed Ceiling U, with R-10 Sheathing

Cavity	Truss Span (ft)												
R-value	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0626	0.0606	0.0590	0.0578	0.0569	0.0561	0.0555	0.0549	0.0545	0.0541	0.0537	0.0534	0.0531
30	0.0458	0.0437	0.0422	0.0410	0.0401	0.0393	0.0387	0.0381	0.0377	0.0373	0.0369	0.0366	0.0363
38	0.0394	0.0374	0.0359	0.0347	0.0337	0.0330	0.0323	0.0318	0.0313	0.0309	0.0305	0.0302	0.0299
49	0.0339	0.0319	0.0304	0.0292	0.0283	0.0275	0.0268	0.0263	0.0258	0.0254	0.0251	0.0247	0.0245

Table A102.2.4(5)
Steel Truss Framed Ceiling U with R-15 Sheathing

Cavity	Truss Span (ft)												
R-value	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0561	0.0550	0.0541	0.0535	0.0530	0.0526	0.0522	0.0519	0.0517	0.0515	0.0513	0.0511	0.0509
30	0.0393	0.0382	0.0373	0.0367	0.0362	0.0358	0.0354	0.0351	0.0349	0.0347	0.0345	0.0343	0.0341
38	0.0329	0.0318	0.0310	0.0303	0.0298	0.0294	0.0291	0.0288	0.0285	0.0283	0.0281	0.0279	0.0278
49	0.0274	0.0263	0.0255	0.0249	0.0244	0.0239	0.0236	0.0233	0.0230	0.0228	0.0226	0.0225	0.0223

Footnotes for Tables A102.2.4(1) through A102.2.4(5)

^a Assembly values based on 24 inch on center truss spacing; 11 Truss member connections penetrating insulation (4 at the eaves, 7 in the interior space); 1/2 inch drywall ceiling; all truss members are 2x4 "C" channels with a solid web. ^bCeiling sheathing installed between bottom chord and drywall.

WAC 51-11C-610225 Tables A102.2.5--Default U-factors for metal building roofs.

Table A102.2.5 Default U-factors for Metal Building Roofs

					for Assembly pted by fram Insul			
Insulation System	Rated R-Value of Insulation	Overall U-Factor for Entire Base Roof Assembly	R-6.5	R-13	R-19.5	R-26	R-32.5	R-39
Standing Seam	Roofs with Thermal S	Spacer Blocks ^{a, b}						
	None	1.280	0.137	0.073	0.049	0.037	0.030	0.025
	R-10	0.115	0.066	0.046	0.035	0.029	0.024	0.021
Single	R-11	0.107	0.063	0.045	0.035	0.028	0.024	0.021
Layer	R-13	0.101	0.061	0.044	0.034	0.028	0.024	0.020
	R-16	0.096	0.059	0.043	0.033	0.027	0.023	0.020
	R-19	0.082	0.053	0.040	0.031	0.026	0.022	0.020
	R-10 + R-10	0.088	0.056	0.041	0.032	0.027	0.023	0.020
	R-10 + R-11	0.086	0.055	0.041	0.032	0.027	0.023	0.020
	R-11 + R-11	0.085	0.055	0.040	0.032	0.026	0.023	0.020
	R-10 + R-13	0.084	0.054	0.040	0.032	0.026	0.023	0.020
Double	R-11 + R-13	0.082	0.053	0.040	0.032	0.026	0.022	0.020
Layer	R-13 + R-13	0.075	0.050	0.038	0.030	0.025	0.022	0.019
	R-10 + R-19	0.074	0.050	0.038	0.030	0.025	0.022	0.019
	R-11 + R-19	0.072	0.049	0.037	0.030	0.025	0.022	0.019
	R-13 + R-19	0.068	0.047	0.036	0.029	0.025	0.021	0.019
	R-16 + R-19	0.065	0.046	0.035	0.029	0.024	0.021	0.018
	R-19 + R-19	0.060	0.043	0.034	0.028	0.023	0.020	0.018
Liner	R-19 + R-11	0.035						
System	R-25 + R-11	0.031						
	R-30 + R-11	0.029						
	R-25 + R-11 + R- 11	0.026						
Filled Cavity v	vith Thermal Spacer B	locks ^c						
	R-10 + R-19	0.057	0.042	0.033	0.027	0.023	0.020	0.018
Standing Seam	Roofs without Therm	al Spacer Blocks						
Liner System	R-19 + R-11	0.040						
Thru-Fastened	Roofs without Therm	al Spacer Blocks						
Single	R-10	0.184						
Layer	R-11	0.182						
	R-13	0.174						
	R-16	0.157						
	R-19	0.151						
Liner System	R-19 + R-11	0.044						

⁽Multiple R-values are listed in order from inside to outside)
^aA standing seam roof clip that provides a minimum 1.5 inch distance between the top of the purlins and the underside of the metal roof panels is required.

bA minimum R-3 thermal spacer block is required.

^cA minimum R-5 thermal spacer block is required.

WAC 51-11C-610226 Tables A102.2.6--Assembly U-factors for roofs with insulation entirely above deck.

Table A102.2.6
Assembly U-factors for Roofs with Insulation Entirely above Deck (Uninterrupted by Framing)

Rated R-Value of Insulation Alone: Minimum Throughout,	Rated R-Value of Insulation Alone: Average (R-5 minimum), Sloped (1/4 inch per foot	Overall U- Factor for Entire
Unsloped R-0	maximum) Not Allowed	Assembly U-1.282
R-0 R-1	Not Allowed Not Allowed	U-1.282 U-0.562
R-1 R-2	Not Allowed	U-0.362 U-0.360
R-3	Not Allowed	U-0.265
R-3 R-4	Not Allowed	U-0.209
	Not Allowed	
R-5 R-6	R-7	U-0.173 U-0.147
R-6 R-7		
	R-8	U-0.129
R-8 R-9	R-9 R-10	U-0.114
R-10	R-10 R-12	U-0.102 U-0.093
R-10	R-12 R-13	
	·	U-0.085
R-12 R-13	R-15	U-0.078
	R-16	U-0.073
R-14	R-18	U-0.068
R-15 R-16	R-20 R-22	U-0.063
_		U-0.060
R-17 R-18	R-23 R-25	U-0.056 U-0.053
R-18 R-19	R-23 R-27	U-0.053 U-0.051
R-19 R-20	R-27 R-29	
R-20	R-29 R-31	U-0.048 U-0.046
R-21 R-22	R-33	U-0.046 U-0.044
R-22 R-23	R-35	U-0.044 U-0.042
R-23 R-24	R-37	U-0.042
R-25	R-39	U-0.039
R-25	R-39 R-41	U-0.039
R-27	R-43	U-0.037
R-27 R-28	R-45 R-46	U-0.035
R-28 R-29	R-48	U-0.033
R-30	R-46 R-50	U-0.034 U-0.032
R-35	R-61	U-0.028
R-33	R-73	U-0.025
R-45	R-86	U-0.022
R-50	R-99	U-0.022
R-55	R-112	U-0.018
R-60	R-126	U-0.016

WAC 51-11C-61030 Section A103--Above grade walls.

NEW SECTION

WAC 51-11C-61031 Section A103.1--General.

A103.1 General. Tables A103.1(1), A103.1(2) and A103.1(3) list heat loss coefficients for the opaque portion of above-grade wood stud frame walls, metal stud frame walls and concrete masonry walls (Btu/h \bullet ft² \bullet °F) respectively. They are derived from procedures listed in the ASHRAE Fundamentals Handbook. For intermediate floor slabs which penetrate the insulated wall, use the concrete wall U-factors in Table A103.1(2).

Insulation is assumed to uniformly fill the entire cavity and to be installed as per manufacturer's directions. All walls are assumed to be finished on the inside with 1/2 inch gypsum wallboard, and on the outside with either beveled wood siding over 1/2 inch plywood sheathing or with 5/8 inch T1-11 siding. Insulated sheathing (either interior or exterior) is assumed to cover the entire opaque wall surface, except where modified in accordance with footnote h to Table C402.1.1.

Metal building walls have a different construction and are addressed in Table A103.3.6.3.

NEW SECTION

WAC 51-11C-61032 Section A103.2--Framing description.

A103.2 Framing description. For wood stud frame walls, three framing types are considered and defined as follows:

A103.2.1 Standard. Studs framed on 16 inch centers with double top plate and single bottom plate. Corners use three studs and each opening is framed using two studs. Headers consist of double 2x or single 4x material with an air space left between the header and the exterior sheathing. Interior partition wall/exterior wall intersections use two studs in the exterior wall.

Standard framing weighting factors:

Studs and plates	0.19
Insulated cavity	0.77
Headers	0.04

A103.2.2 Intermediate. Studs framed on 16 inch centers with double

top plate and single bottom plate. Corners use two studs or other means of fully insulating corners, and each opening is framed by two studs. Headers consist of double 2x material with R-10 insulation. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Intermediate framing weighting factors:

Studs and plates	0.18
Insulated cavity	0.78
Headers	0.04

A103.2.3 Advanced. Studs framed on 24 inch centers with double top plate and single bottom plate. Corners use two studs or other means of fully insulating corners, and one stud is used to support each header. Headers consist of double 2x material with R-10 insulation. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Advanced framing weighting factors:

Studs and plates	0.13
Insulated cavity	0.83
Headers	0.04

NEW SECTION

WAC 51-11C-61033 Section A103.3--Component description.

A103.3 Component description. Default coefficients for the following types of walls are listed: Single-stud walls, strap walls, double-stud walls, log walls, stress-skin panels, metal stud walls, and metal building walls.

NEW SECTION

WAC 51-11C-610331 Section A103.3.1--Single stud wall.

A103.3.1 Single-stud wall. Tables A103.3.1(1) through A103.3.1(8): Assumes either 2 x 4 or 2 x 6 studs framed on 16 or 24 inch centers. Headers are solid for 2 x 4 walls and double 2x for 2 x 6 walls, with either dead-air or rigid-board insulation in the remaining space.

TABLE A103.3.1(1)

2 x 4 Single Wood Stud: R-11 Batt

Siding Material/Framing Type

	Lapped	l Wood	T1-11	
R-value of Foam Board	STD	ADV	STD	ADV
0	0.088	0.084	0.094	0.090
1	0.080	0.077	0.085	0.082
2	0.074	0.071	0.078	0.075
3	0.069	0.066	0.072	0.070
4	0.064	0.062	0.067	0.065
5	0.060	0.058	0.063	0.061
6	0.056	0.055	0.059	0.057
7	0.053	0.052	0.055	0.054
8	0.051	0.049	0.052	0.051
9	0.048	0.047	0.050	0.049
10	0.046	0.045	0.047	0.046
11	0.044	0.043	0.045	0.044
12	0.042	0.041	0.043	0.042
	Foam Board 0 1 2 3 4 5 6 7 8 9 10	R-value of Foam Board STD 0 0.088 1 0.080 2 0.074 3 0.069 4 0.064 5 0.060 6 0.056 7 0.053 8 0.051 9 0.048 10 0.046 11 0.044	Foam Board STD ADV 0 0.088 0.084 1 0.080 0.077 2 0.074 0.071 3 0.069 0.066 4 0.064 0.062 5 0.060 0.058 6 0.056 0.055 7 0.053 0.052 8 0.051 0.049 9 0.048 0.047 10 0.046 0.045 11 0.044 0.043	R-value of Foam Board STD ADV STD 0 0.088 0.084 0.094 1 0.080 0.077 0.085 2 0.074 0.071 0.078 3 0.069 0.066 0.072 4 0.064 0.062 0.067 5 0.060 0.058 0.063 6 0.056 0.055 0.059 7 0.053 0.052 0.055 8 0.051 0.049 0.052 9 0.048 0.047 0.050 10 0.046 0.045 0.047 11 0.044 0.043 0.045

TABLE A103.3.1(2)

2 x 4 Single Wood Stud: R-13 Batt

Siding Material/Framing Type

	Siding Waterland Laming Type						
		Lappe	d Wood	T1	-11		
	R-value of						
	Foam Board	STD	ADV	STD	ADV		
NOTE:	0	0.082	0.078	0.088	0.083		
Nominal Batt R-value:	1	0.075	0.072	0.080	0.076		
R-13 at 3.63 inch thickness	2	0.069	0.066	0.073	0.070		
Installed Batt R-value:	3	0.065	0.062	0.068	0.065		
R-12.7 in 3.5 inch cavity	4	0.060	0.058	0.063	0.061		
it 12.7 in 5.5 men euvity	5	0.057	0.055	0.059	0.057		
	6	0.053	0.052	0.056	0.054		
	7	0.051	0.049	0.052	0.051		
	8	0.048	0.047	0.050	0.048		
	9	0.046	0.045	0.047	0.046		
	10	0.044	0.043	0.045	0.044		
	11	0.042	0.041	0.043	0.042		
	12	0.040	0.039	0.041	0.040		

TABLE A103.3.1(3)

2 x 4 Single Wood Stud: R-15 Batt

Siding Material/Framing Type

		Lapped Wood		T1-11	
	R-value of Foam Board	STD	ADV	STD	ADV
NOTE:	0	0.076	0.071	0.081	0.075
Nominal Batt R-value:	1	0.069	0.065	0.073	0.069
R-15 at 3.5 inch thickness	2	0.064	0.061	0.068	0.069
Installed Batt R-value:	3	0.060	0.057	0.063	0.059
R-15 in 3.5 inch cavity	4	0.056	0.053	0.059	0.056
	5	0.053	0.051	0.055	0.052
	6	0.050	0.048	0.052	0.050
	7	0.047	0.046	0.049	0.047
	8	0.045	0.044	0.047	0.045
	9	0.043	0.042	0.044	0.043
	10	0.041	0.040	0.042	0.041
	11	0.039	0.038	0.041	0.039
	12	0.038	0.037	0.039	0.038

TABLE A103.3.1(4)

2 x 6 Single Wood Stud: R-19 Batt

	Siding Material/Framing Type						
		La	pped Wo	od		T1-11	
	R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
NOTE:	0	0.062	0.058	0.055	0.065	0.061	0.058
Nominal Batt R-value:	1	0.058	0.055	0.052	0.060	0.057	0.055
R-19 at 6 inch thickness	2	0.054	0.052	0.050	0.056	0.054	0.051
Installed Batt R-value:	3	0.051	0.049	0.047	0.053	0.051	0.049
R-18 in 5.5 inch cavity	4	0.048	0.046	0.045	0.050	0.048	0.046
	5	0.046	0.044	0.043	0.048	0.046	0.044
	6	0.044	0.042	0.041	0.045	0.044	0.042
	7	0.042	0.040	0.039	0.043	0.042	0.040
	8	0.040	0.039	0.038	0.041	0.040	0.039
	9	0.038	0.037	0.035	0.039	0.038	0.037
	10	0.037	0.036	0.035	0.038	0.037	0.036
	11	0.036	0.035	0.034	0.036	0.035	0.035
	12	0.034	0.033	0.033	0.035	0.034	0.033

TABLE A103.3.1(5)

2 x 6 Single Wood Stud: R-21 Batt

Siding Material/Framing Type
Lapped Wood T1-11

	R-value of						
	Foam Board	STD	INT	ADV	STD	INT	ADV
NOTE:	0	0.057	0.054	0.051	0.060	0.056	0.053
Nominal Batt R-value:	1	0.054	0.051	0.048	0.056	0.053	0.050
Nominal Batt R-value: R-21 at 5.5 inch thickness Installed Batt R-value: R-21 in 5.5 inch cavity	2	0.050	0.048	0.045	0.052	0.050	0.047
Installed Batt R-value:	3	0.048	0.045	0.043	0.049	0.047	0.045
	4	0.045	0.043	0.041	0.047	0.045	0.043
	5	0.043	0.041	0.040	0.044	0.042	0.041
	6	0.041	0.039	0.038	0.042	0.041	0.039
	7	0.039	0.038	0.036	0.040	0.039	0.037
	8	0.038	0.036	0.035	0.039	0.037	0.036
	9	0.036	0.035	0.034	0.037	0.036	0.035
	10	0.035	0.034	0.033	0.036	0.035	0.033
	11	0.033	0.033	0.032	0.034	0.033	0.032
	12	0.032	0.031	0.031	0.033	0.032	0.031

TABLE A103.3.1(6)

2 x 6 Single Wood Stud: R-22 Batt

	Siding Material/Framing Type						
		Lapped Wood			T1-11		
	R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
NOTE:	0	0.059	0.055	0.052	0.062	0.058	0.054
Nominal Batt R-value:	1	0.055	0.052	0.049	0.057	0.054	0.051
R-22 at 6.75 inch thickness	2	0.052	0.049	0.047	0.054	0.051	0.048
Installed Batt R-value:	3	0.049	0.046	0.044	0.050	0.048	0.046
R-20 in 5.5 inch cavity	4	0.046	0.044	0.042	0.048	0.046	0.044
,	5	0.044	0.042	0.041	0.045	0.043	0.042
	6	0.042	0.040	0.039	0.043	0.042	0.040
	7	0.040	0.039	0.037	0.041	0.040	0.038
	8	0.038	0.037	0.036	0.039	0.038	0.037
	9	0.037	0.036	0.035	0.038	0.037	0.035
	10	0.035	0.034	0.033	0.036	0.035	0.034
	11	0.034	0.033	0.032	0.035	0.034	0.033
	12	0.033	0.032	0.031	0.034	0.033	0.032

TABLE A103.3.1(7)

2 x 6 Single Wood Stud: Two R-11 Batts

Siding Material/Framing Type Lapped Wood T1-11 R-value of Foam Board **STD STD** INT ADV INT ADV NOTE: 0 0.060 0.057 0.054 0.063 0.059 0.056 1 0.056 0.053 0.051 0.059 0.053 Nominal Batt R-value: 0.056 R-22 at 7 inch thickness 2 0.053 0.050 0.048 0.055 0.052 0.050 3 0.050 0.048 0.046 0.052 0.049 0.047 Installed Batt R-value: 4 0.045 0.044 0.049 0.047 0.045 R-18.9 in 5.5 inch cavity 0.047 5 0.045 0.043 0.042 0.046 0.045 0.043 6 0.043 0.041 0.040 0.044 0.043 0.041 7 0.041 0.040 0.038 0.042 0.041 0.039 8 0.039 0.038 0.037 0.040 0.039 0.038 9 0.038 0.037 0.036 0.039 0.038 0.036 10 0.036 0.035 0.034 0.037 0.036 0.035 11 0.035 0.034 0.033 0.036 0.035 0.034 12 0.034 0.033 0.034 0.033 0.032 0.034

TABLE A103.3.1(8)

2 x 8 Single Stud: R-25 Batt

	Siding Material/Framing Type						
	Lapped Wood			T1-11			
	R-value of Foam Board	STD	INT	ADV	STD	INT	ADV
NOTE:	0	0.051	0.047	0.045	0.053	0.049	0.046
Nominal Batt R-value:	1	0.048	0.045	0.043	0.049	0.046	0.044
	2	0.045	0.043	0.041	0.047	0.044	0.042
Installed Batt R-value:	3	0.043	0.041	0.039	0.044	0.042	0.040
R-23.6 in 7.25 inch cavity	4	0.041	0.039	0.037	0.042	0.040	0.038
	5	0.039	0.037	0.036	0.040	0.038	0.037
	6	0.037	0.036	0.035	0.038	0.037	0.036
	7	0.036	0.035	0.033	0.037	0.035	0.034
	8	0.035	0.033	0.032	0.035	0.034	0.033
	9	0.033	0.032	0.031	0.034	0.033	0.032
	10	0.032	0.031	0.030	0.033	0.032	0.031
	11	0.031	0.030	0.029	0.032	0.031	0.030
	12	0.030	0.029	0.028	0.031	0.030	0.029

WAC 51-11C-610332 Section A103.3.2--Strap wall.

A103.3.2 Strap wall. Table A103.3.2: Assumes 2 \times 6 studs framed on 16 or 24 inch centers. 2 \times 3 or 2 \times 4 strapping is run horizontally along the interior surface of the wall to provide additional space for insulation.

Table A103.3.2 2 x 6: Strap Wall

	Siding Material/Frame Type					
	Lappeo	d Wood	T	1-11		
	STD	ADV	STD	ADV		
R-19 + R-11 Batts	0.036	0.035	0.038	0.036		
R-19 + R-8 Batts	0.041	0.039	0.042	0.040		

NEW SECTION

WAC 51-11C-610333 Section A103.3.3--Double stud wall.

A103.3.3 Double stud wall. Tables A103.3.3(1) and A103.3.3(2): Assumes an exterior structural wall and a separate interior, nonstructural wall. Insulation is placed in both wall cavities and in the space between the two walls. Stud spacing is assumed to be on 24 inch centers for both walls.

Table A103.3.3(1) $2 \times 6 + 2 \times 4$: Double Wood Stud

			Siding Material/Frame Type				
	Batt Configuration		Lapped \	Lapped Wood T1-11			
Exterior	Middle	Interior	STD	ADV	STD	ADV	
R-19		R-11	0.040	0.037	0.041	0.038	
R-19		R-19	0.034	0.031	0.035	0.032	
R-19	R-8	R-11	0.029	0.028	0.031	0.029	
R-19	R-11	R-11	0.027	0.026	0.028	0.027	
R-19	R-11	R-19	0.024	0.023	0.025	0.023	
R-19	R-19	R-19	0.021	0.020	0.021	0.020	

Table A103.3.3(2)

 $2 \times 4 + 2 \times 4$: Double Wood Stud

			Siding Material/Frame Type				
Batt Configuration			Lapped	Wood	T1-11		
Exterior	Middle	Interior	STD	ADV	STD	ADV	
R-11		R-11	0.050	0.046	0.052	0.048	

			Siding Material/Frame Type				
	Batt Configuration	Lapped	Wood	T1	-11		
Exterior	Middle	Interior	STD ADV		STD	ADV	
R-19		R-11	0.039	0.037	0.043	0.039	
R-11	R-8	R-11	0.037	0.035	0.036	0.036	
R-11	R-11	R-11	0.032	0.031	0.033	0.032	
R-13	R-13	R-13	0.029	0.028	0.029	0.028	
R-11	R-19	R-11	0.026	0.026	0.027	0.026	

WAC 51-11C-610334 Section A103.3.4--Log wall.

A103.3.4 Log wall. See Table A103.3.4.

Table A103.3.4 Log Walls

	Average Log Diameter, Inches	U-factor
NOTE: R-value of	6	0.148
wood:	8	0.111
R-1.25 per inch thickness	10	0.089
	12	0.074
Average wall thickness 90% average log	14	0.063
diameter	16	0.056

NEW SECTION

WAC 51-11C-610335 Section A103.3.5--Stress skin panel.

A103.3.5 Stress-skin panel. See Table A103.3.5.

Table A103.3.5 Stress Skin Panel

	Panel Thickness, Inches	U-factor
NOTE: R-value of	3 1/2	0.071
expanded polystyrene: R-3.85 per inch	5 1/2	0.048
	7 1/4	0.037
	9 1/4	0.030
Framing: 6% Spline: 8%	11 1/4	0.025

No thermal bridging between interior and exterior splines

NEW SECTION

WAC 51-11C-610336 Section A103.3.6--Metal stud walls.

A103.3.6 Metal stud walls. The nominal R-values in Tables A103.3.6.1 through A103.3.6.3 may be used for purposes of calculating metal stud wall section U-factors in lieu of the ASHRAE zone calculation method as provided in Chapter 27 of the ASHRAE Fundamentals Handbook.

A103.3.6.1 Metal stud wall, overall assembly U-factors. Tables A103.3.6.1(1) and A103.6.1(2): Assumes metal studs spaced on 16 or 24 inch centers with insulation installed to fill wall cavities. Continuous rigid board insulation is applied without creating uninsulated voids in the wall assembly.

Table A103.3.6.1(1)
Overall Assembly U-factors for Metal Stud Walls with Continuous
Insulation

				Cavity	Insulation		
Metal Framing	R-Value of Continuous Foam Board Insulation	R-0	R-11	R-13	R-15	R-19	R-21
16" o.c.	R-0 (none)	0.352	0.132	0.124	0.118	0.109	0.106
	R-1	0.260	0.117	0.111	0.106	0.099	0.096
	R-2	0.207	0.105	0.100	0.096	0.090	0.087
	R-3	0.171	0.095	0.091	0.087	0.082	0.080
	R-4	0.146	0.087	0.083	0.080	0.076	0.074
	R-5	0.128	0.080	0.077	0.074	0.071	0.069
	R-6	0.113	0.074	0.071	0.069	0.066	0.065
	R-7	0.102	0.069	0.066	0.065	0.062	0.061
	R-8	0.092	0.064	0.062	0.061	0.058	0.057

				Cavity	Insulation		
Metal Framing	R-Value of Continuous Foam Board Insulation	R-0	R-11	R-13	R-15	R-19	R-21
	R-9	0.084	0.060	0.059	0.057	0.055	0.054
	R-10	0.078	0.057	0.055	0.054	0.052	0.051
	R-11	0.072	0.054	0.052	0.051	0.050	0.049
	R-12	0.067	0.051	0.050	0.049	0.047	0.047
	R-13	0.063	0.049	0.048	0.047	0.045	0.045
	R-14	0.059	0.046	0.045	0.045	0.043	0.043
	R-15	0.056	0.044	0.043	0.043	0.041	0.041
	R-20	0.044	0.036	0.036	0.035	0.034	0.034
24" o.c.	R-0 (none)	0.338	0.116	0.108	0.102	0.094	0.090
	R-1	0.253	0.104	0.098	0.092	0.086	0.083
	R-2	0.202	0.094	0.089	0.084	0.079	0.077
	R-3	0.168	0.086	0.082	0.078	0.073	0.071
	R-4	0.144	0.079	0.075	0.072	0.068	0.066
	R-5	0.126	0.073	0.070	0.067	0.064	0.062
	R-6	0.112	0.068	0.066	0.063	0.060	0.059
	R-7	0.100	0.064	0.062	0.059	0.057	0.055
	R-8	0.091	0.060	0.058	0.056	0.054	0.052
	R-9	0.084	0.057	0.055	0.053	0.051	0.050
	R-10	0.077	0.054	0.052	0.050	0.048	0.048
	R-11	0.072	0.051	0.049	0.048	0.046	0.045
	R-12	0.067	0.048	0.047	0.046	0.044	0.043
	R-13	0.063	0.046	0.045	0.044	0.042	0.042
	R-14	0.059	0.044	0.043	0.042	0.041	0.040
	R-15	0.056	0.042	0.041	0.040	0.039	0.038
	R-20	0.044	0.035	0.034	0.034	0.033	0.032

Continuous foam board insulation: Continuous insulation assumes no thermal bridging of insulation by framing or z-furring through applied foam board. Zone calculation method as provided in the ASHRAE Fundamentals Handbook must be used for thermally bridged foam board insulation. Values for attachment of insulation with z-furring are given in Table A103.3.6.1(2).

Table A103.3.6.1(2)
Overall Assembly U-factors for Metal Stud Walls with Insulation
Supported by Z-furring

				Cavity Insulation						
Metal Framing	R-Value of Foam Board Insulation	Z-furring Attachment	R-0	R-11	R-13	R-15	R-19	R-21		
16" o.c.	R-0 (none)	Horizontal	0.352	0.132	0.124	0.118	0.109	0.106		
	R-5	Horizontal	0.155	0.089	0.086	0.083	0.078	0.077		
	R-7.5	Horizontal	0.128	0.080	0.077	0.074	0.071	0.069		

R-10						Cavity	Insulation		
R-12.5		Foam Board		R-0	R-11	R-13	R-15	R-19	R-21
R-15		R-10		0.110	0.072	0.070	0.068	0.065	0.064
R-17.5		R-12.5	Horizontal	0.099	0.068	0.065	0.064	0.061	0.060
R-20		R-15	Horizontal	0.091	0.064	0.062	0.060	0.058	0.057
R-22.5 Horizontal 0.074 0.055 0.054 0.052 0.051 0.050		R-17.5	Horizontal	0.084	0.060	0.058	0.057	0.055	0.054
R-25		R-20	Horizontal	0.078	0.057	0.056	0.054	0.052	0.052
R-0 (none) Vertical 0.352 0.132 0.124 0.118 0.109 0.106		R-22.5	Horizontal	0.074	0.055	0.054	0.052	0.051	0.050
R-5		R-25	Horizontal	0.071	0.053	0.052	0.051	0.049	0.048
R-7.5 Vertical 0.142 0.085 0.081 0.079 0.075 0.073 R-10 Vertical 0.126 0.079 0.076 0.074 0.070 0.069 R-12.5 Vertical 0.115 0.074 0.072 0.070 0.066 0.065 R-15 Vertical 0.107 0.071 0.069 0.067 0.064 0.063 R-17.5 Vertical 0.100 0.068 0.065 0.064 0.061 0.060 R-20 Vertical 0.094 0.065 0.063 0.061 0.059 0.058 R-22.5 Vertical 0.096 0.061 0.059 0.058 0.056 0.055 0.063 0.061 0.059 0.058 0.056 0.055 0.063 0.061 0.060 0.057 0.056 0.055 0.063 0.061 0.060 0.057 0.056 0.055 0.063 0.061 0.060 0.057 0.056 0.055 0.055		R-0 (none)	Vertical	0.352	0.132	0.124	0.118	0.109	0.106
R-10		R-5	Vertical	0.165	0.093	0.089	0.086	0.081	0.079
R-12.5 Vertical 0.115 0.074 0.072 0.070 0.066 0.065		R-7.5	Vertical	0.142	0.085	0.081	0.079	0.075	0.073
R-15		R-10	Vertical	0.126	0.079	0.076	0.074	0.070	0.069
R-17.5 Vertical 0.100 0.068 0.065 0.064 0.061 0.060 R-20		R-12.5	Vertical	0.115	0.074	0.072	0.070	0.066	0.065
R-20		R-15	Vertical	0.107	0.071	0.069	0.067	0.064	0.063
R-22.5 Vertical 0.090 0.063 0.061 0.060 0.057 0.056 R-25		R-17.5	Vertical	0.100	0.068	0.065	0.064	0.061	0.060
R-25 Vertical 0.086 0.061 0.059 0.058 0.056 0.055		R-20	Vertical	0.094	0.065	0.063	0.061	0.059	0.058
R-0 (none)		R-22.5	Vertical	0.090	0.063	0.061	0.060	0.057	0.056
R-5 Horizontal 0.152 0.082 0.078 0.074 0.070 0.068 R-7.5 Horizontal 0.126 0.074 0.070 0.068 0.064 0.062 R-10 Horizontal 0.109 0.067 0.065 0.062 0.059 0.058 R-12.5 Horizontal 0.098 0.063 0.061 0.059 0.056 0.055 R-15 Horizontal 0.090 0.060 0.058 0.056 0.053 0.052 R-17.5 Horizontal 0.083 0.057 0.055 0.053 0.051 0.050 R-20 Horizontal 0.078 0.054 0.052 0.051 0.049 0.047 0.046 R-25 Horizontal 0.074 0.052 0.050 0.049 0.047 0.046 0.045 R-0 (none) Vertical 0.338 0.116 0.108 0.102 0.094 0.090 R-5 Vertical 0.162 0.084 0.080		R-25	Vertical	0.086	0.061	0.059	0.058	0.056	0.055
R-7.5 Horizontal 0.126 0.074 0.070 0.068 0.064 0.062 R-10 Horizontal 0.109 0.067 0.065 0.062 0.059 0.058 R-12.5 Horizontal 0.098 0.063 0.061 0.059 0.056 0.055 R-15 Horizontal 0.090 0.060 0.058 0.056 0.053 0.052 R-17.5 Horizontal 0.083 0.057 0.055 0.053 0.051 0.050 R-20 Horizontal 0.078 0.054 0.052 0.051 0.049 0.048 R-22.5 Horizontal 0.074 0.052 0.050 0.049 0.047 0.046 R-25 Horizontal 0.070 0.050 0.049 0.047 0.046 R-0 (none) Vertical 0.338 0.116 0.108 0.102 0.094 0.094 R-7.5 Vertical 0.162 0.084 0.080 0.077 0.072 0.070 <td>24" o.c.</td> <td>R-0 (none)</td> <td>Horizontal</td> <td>0.338</td> <td>0.116</td> <td>0.108</td> <td>0.102</td> <td>0.094</td> <td>0.090</td>	24" o.c.	R-0 (none)	Horizontal	0.338	0.116	0.108	0.102	0.094	0.090
R-10 Horizontal 0.109 0.067 0.065 0.062 0.059 0.058 R-12.5 Horizontal 0.098 0.063 0.061 0.059 0.056 0.055 R-15 Horizontal 0.090 0.060 0.058 0.056 0.053 0.052 R-17.5 Horizontal 0.083 0.057 0.055 0.053 0.051 0.050 R-20 Horizontal 0.078 0.054 0.052 0.051 0.049 0.049 0.047 0.046 R-22.5 Horizontal 0.074 0.052 0.050 0.049 0.047 0.046 0.045 R-25 Horizontal 0.070 0.050 0.049 0.047 0.046 0.045 R-0 (none) Vertical 0.338 0.116 0.108 0.102 0.094 0.090 R-5 Vertical 0.162 0.084 0.080 0.077 0.072 0.070 R-7.5 Vertical 0.140 0.078		R-5	Horizontal	0.152	0.082	0.078	0.074	0.070	0.068
R-12.5 Horizontal 0.098 0.063 0.061 0.059 0.056 0.055 R-15 Horizontal 0.090 0.060 0.058 0.056 0.053 0.052 R-17.5 Horizontal 0.083 0.057 0.055 0.053 0.051 0.050 R-20 Horizontal 0.078 0.054 0.052 0.051 0.049 0.048 R-22.5 Horizontal 0.074 0.052 0.050 0.049 0.047 0.046 R-25 Horizontal 0.070 0.050 0.049 0.047 0.046 R-0 (none) Vertical 0.338 0.116 0.108 0.102 0.094 0.094 R-5 Vertical 0.162 0.084 0.080 0.077 0.072 0.070 R-7.5 Vertical 0.140 0.078 0.074 0.071 0.067 0.065 R-10 Vertical 0.113 0.069 0.066 0.064 0.061 0.059		R-7.5	Horizontal	0.126	0.074	0.070	0.068	0.064	0.062
R-15 Horizontal 0.090 0.060 0.058 0.056 0.053 0.052 R-17.5 Horizontal 0.083 0.057 0.055 0.053 0.051 0.050 R-20 Horizontal 0.078 0.054 0.052 0.051 0.049 0.048 R-22.5 Horizontal 0.074 0.052 0.050 0.049 0.047 0.046 R-25 Horizontal 0.070 0.050 0.049 0.047 0.046 0.045 R-0 (none) Vertical 0.338 0.116 0.108 0.102 0.094 0.090 R-5 Vertical 0.162 0.084 0.080 0.077 0.072 0.070 R-7.5 Vertical 0.140 0.078 0.074 0.071 0.067 0.065 R-10 Vertical 0.124 0.073 0.070 0.067 0.063 0.062 R-15 Vertical 0.106 0.066 0.063 0.061 0.058		R-10	Horizontal	0.109	0.067	0.065	0.062	0.059	0.058
R-17.5 Horizontal 0.083 0.057 0.055 0.053 0.051 0.050 R-20 Horizontal 0.078 0.054 0.052 0.051 0.049 0.048 R-22.5 Horizontal 0.074 0.052 0.050 0.049 0.047 0.046 R-25 Horizontal 0.070 0.050 0.049 0.047 0.046 0.045 R-0 (none) Vertical 0.338 0.116 0.108 0.102 0.094 0.094 R-5 Vertical 0.162 0.084 0.080 0.077 0.072 0.070 R-7.5 Vertical 0.140 0.078 0.074 0.071 0.067 0.065 R-10 Vertical 0.124 0.073 0.070 0.067 0.063 0.062 R-12.5 Vertical 0.113 0.069 0.066 0.064 0.061 0.059 R-17.5 Vertical 0.098 0.063 0.061 0.058 0.055 <		R-12.5	Horizontal	0.098	0.063	0.061	0.059	0.056	0.055
R-20 Horizontal 0.078 0.054 0.052 0.051 0.049 0.048 R-22.5 Horizontal 0.074 0.052 0.050 0.049 0.047 0.046 R-25 Horizontal 0.070 0.050 0.049 0.047 0.046 0.045 R-0 (none) Vertical 0.338 0.116 0.108 0.102 0.094 0.090 R-5 Vertical 0.162 0.084 0.080 0.077 0.072 0.070 R-7.5 Vertical 0.140 0.078 0.074 0.071 0.067 0.065 R-10 Vertical 0.124 0.073 0.070 0.067 0.063 0.062 R-12.5 Vertical 0.113 0.069 0.066 0.064 0.061 0.059 R-15 Vertical 0.106 0.066 0.063 0.061 0.058 0.057 R-20 Vertical 0.093 0.061 0.059 0.055 0.053 <td< td=""><td></td><td>R-15</td><td>Horizontal</td><td>0.090</td><td>0.060</td><td>0.058</td><td>0.056</td><td>0.053</td><td>0.052</td></td<>		R-15	Horizontal	0.090	0.060	0.058	0.056	0.053	0.052
R-22.5 Horizontal 0.074 0.052 0.050 0.049 0.047 0.046 R-25 Horizontal 0.070 0.050 0.049 0.047 0.046 0.045 R-0 (none) Vertical 0.338 0.116 0.108 0.102 0.094 0.090 R-5 Vertical 0.162 0.084 0.080 0.077 0.072 0.070 R-7.5 Vertical 0.140 0.078 0.074 0.071 0.067 0.065 R-10 Vertical 0.124 0.073 0.070 0.067 0.063 0.062 R-12.5 Vertical 0.113 0.069 0.066 0.064 0.061 0.059 R-15 Vertical 0.106 0.066 0.063 0.061 0.058 0.057 R-17.5 Vertical 0.098 0.063 0.061 0.059 0.056 0.053 R-20 Vertical 0.089 0.059 0.057 0.055 0.053 <td< td=""><td></td><td>R-17.5</td><td>Horizontal</td><td>0.083</td><td>0.057</td><td>0.055</td><td>0.053</td><td>0.051</td><td>0.050</td></td<>		R-17.5	Horizontal	0.083	0.057	0.055	0.053	0.051	0.050
R-25 Horizontal 0.070 0.050 0.049 0.047 0.046 0.045 R-0 (none) Vertical 0.338 0.116 0.108 0.102 0.094 0.090 R-5 Vertical 0.162 0.084 0.080 0.077 0.072 0.070 R-7.5 Vertical 0.140 0.078 0.074 0.071 0.067 0.065 R-10 Vertical 0.124 0.073 0.070 0.067 0.063 0.062 R-12.5 Vertical 0.113 0.069 0.066 0.064 0.061 0.059 R-15 Vertical 0.106 0.066 0.063 0.061 0.058 0.057 R-17.5 Vertical 0.098 0.063 0.061 0.059 0.056 0.055 R-20 Vertical 0.089 0.059 0.057 0.055 0.053 R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053		R-20	Horizontal	0.078	0.054	0.052	0.051	0.049	0.048
R-0 (none) Vertical 0.338 0.116 0.108 0.102 0.094 0.090 R-5 Vertical 0.162 0.084 0.080 0.077 0.072 0.070 R-7.5 Vertical 0.140 0.078 0.074 0.071 0.067 0.065 R-10 Vertical 0.124 0.073 0.070 0.067 0.063 0.062 R-12.5 Vertical 0.113 0.069 0.066 0.064 0.061 0.059 R-15 Vertical 0.106 0.066 0.063 0.061 0.058 0.057 R-17.5 Vertical 0.098 0.063 0.061 0.059 0.056 0.054 0.053 R-20 Vertical 0.089 0.059 0.057 0.055 0.053 0.051 R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053 0.051		R-22.5	Horizontal	0.074	0.052	0.050	0.049	0.047	0.046
R-5 Vertical 0.162 0.084 0.080 0.077 0.072 0.070 R-7.5 Vertical 0.140 0.078 0.074 0.071 0.067 0.065 R-10 Vertical 0.124 0.073 0.070 0.067 0.063 0.062 R-12.5 Vertical 0.113 0.069 0.066 0.064 0.061 0.059 R-15 Vertical 0.106 0.066 0.063 0.061 0.058 0.057 R-17.5 Vertical 0.098 0.063 0.061 0.059 0.056 0.055 R-20 Vertical 0.093 0.061 0.059 0.057 0.054 0.053 R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053 0.051		R-25	Horizontal	0.070	0.050	0.049	0.047	0.046	0.045
R-7.5 Vertical 0.140 0.078 0.074 0.071 0.067 0.065 R-10 Vertical 0.124 0.073 0.070 0.067 0.063 0.062 R-12.5 Vertical 0.113 0.069 0.066 0.064 0.061 0.059 R-15 Vertical 0.106 0.066 0.063 0.061 0.058 0.057 R-17.5 Vertical 0.098 0.063 0.061 0.059 0.056 0.055 R-20 Vertical 0.093 0.061 0.059 0.057 0.054 0.053 R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053 0.051		R-0 (none)	Vertical	0.338	0.116		0.102		0.090
R-10 Vertical 0.124 0.073 0.070 0.067 0.063 0.062 R-12.5 Vertical 0.113 0.069 0.066 0.064 0.061 0.059 R-15 Vertical 0.106 0.066 0.063 0.061 0.058 0.057 R-17.5 Vertical 0.098 0.063 0.061 0.059 0.056 0.055 R-20 Vertical 0.093 0.061 0.059 0.057 0.054 0.053 R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053 0.051		R-5	Vertical	0.162	0.084	0.080	0.077	0.072	0.070
R-10 Vertical 0.124 0.073 0.070 0.067 0.063 0.062 R-12.5 Vertical 0.113 0.069 0.066 0.064 0.061 0.059 R-15 Vertical 0.106 0.066 0.063 0.061 0.058 0.057 R-17.5 Vertical 0.098 0.063 0.061 0.059 0.056 0.055 R-20 Vertical 0.093 0.061 0.059 0.057 0.054 0.053 R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053 0.051									0.065
R-12.5 Vertical 0.113 0.069 0.066 0.064 0.061 0.059 R-15 Vertical 0.106 0.066 0.063 0.061 0.058 0.057 R-17.5 Vertical 0.098 0.063 0.061 0.059 0.056 0.055 R-20 Vertical 0.093 0.061 0.059 0.057 0.054 0.053 R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053 0.051									0.062
R-15 Vertical 0.106 0.066 0.063 0.061 0.058 0.057 R-17.5 Vertical 0.098 0.063 0.061 0.059 0.056 0.055 R-20 Vertical 0.093 0.061 0.059 0.057 0.054 0.053 R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053 0.051									0.059
R-17.5 Vertical 0.098 0.063 0.061 0.059 0.056 0.055 R-20 Vertical 0.093 0.061 0.059 0.057 0.054 0.053 R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053 0.051							0.061		0.057
R-20 Vertical 0.093 0.061 0.059 0.057 0.054 0.053 R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053 0.051									0.055
R-22.5 Vertical 0.089 0.059 0.057 0.055 0.053 0.051									0.053
R-25 Vertical 0.085 0.057 0.055 0.054 0.051 0.050		R-25	Vertical	0.085	0.057	0.055	0.054	0.051	0.050

Values in Table A103.3.6.1(2) may not be interpolated between. The value of the foam board insulation must meet or exceed the value listed in the table in order to use the value shown.

A103.3.6.2 Metal stud wall, effective R-values for metal framing and cavity only. Table A103.3.6.2: These values may be used for

the metal-framing/cavity layers in walls with metal studs spaced on 16- or 24-inch centers with insulation installed to fill wall cavities in lieu of using the zone method provided in Chapter 25 of the ASHRAE Fundamentals Handbook.

Table A103.3.6.2
Effective R-values for Metal Framing and Cavity Only

		Cavity		Insulation	
	Nominal	Actual	Nominal	Effective	R-Value
	Depth, Inches	Depth, Inches	R-Value	16" O.C.	24" O.C.
Air Cavity	any	any	R-0.91 (air)	0.79	0.91
	4	3-1/2	R-11	5.5	6.6
	4	3-1/2	R-13	6.0	7.2
Wall	4	3-1/2	R-15	6.4	7.8
	6	5-1/2	R-19	7.1	8.6
	6	5-1/2	R-21	7.4	9.0
	8	7-1/4	R-25	7.8	9.6
Roof		Insulation is uncompressed	R-11	5.5	6.1
			R-19	7.0	9.1
			R-30	9.3	11.4

A103.3.6.3 Metal building wall. Table A103.3.6.3: A wall whose structure consists of metal spanning panels supported by steel structural members (does not include spandrel glass or metal panels in curtain wall systems). The first nominal R-value is for insulation compressed between metal wall panels and the steel structure. For double-layer installations, the second rated R-value of insulation is for insulation installed from the inside, covering the girts. For continuous insulation (e.g., insulation boards) it is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the conditioned space or semi-heated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

Table A103.3.6.3
Default Metal Building Wall U-factors

				Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing)					
Insulation System	Rated R- Value of Insulation	Overall U- Factor for Entire Base Wall Assembly	R-6.5	R-13	R-19.5	R-26	R-32.5	R-39	
Sing	le Layer of Min	eral Fiber							
	None	1.180	0.136	0.072	0.049	0.037	0.030	0.025	
	R-10	0.186	0.084	0.054	0.040	0.032	0.026	0.023	
	R-11	0.185	0.084	0.054	0.040	0.032	0.026	0.023	
	R-13	0.162	0.079	0.052	0.039	0.031	0.026	0.022	

		Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing)					
R-16	0.155	0.077	0.051	0.039	0.031	0.026	0.022
R-19	0.147	0.075	0.050	0.038	0.030	0.025	0.022

WAC 51-11C-610337 Section A103.3.7--Concrete and masonry walls.

A103.3.7 Concrete and masonry walls.

A103.3.7.1 Concrete masonry walls. The nominal R-values in Table A103.3.7.1 may be used for purposes of calculating concrete masonry wall section U-factors in lieu of the ASHRAE isothermal planes calculation method as provided in Chapter 27 of the ASHRAE Fundamentals Handbook.

Table A103.3.7.1(1) Default U-factors for Concrete and Masonry Walls

8" Concrete Masonry

		CORE TREATMENT						
	Partial G	Frout with Ungre	outed Cores					
		Loose-fil	l insulated					
Wall Description	Empty	Perlite	Vermiculite	Solid Grout				
Exposed Block, Both Sides	0.40	0.23	0.24	0.43				
R-5 Interior Insulation, Wood Furring	0.14	0.11	0.12	0.15				
R-6 Interior Insulation, Wood Furring	0.14	0.11	0.11	0.14				
R-10.5 Interior Insulation, Wood Furring	0.11	0.09	0.09	0.11				
R-8 Interior Insulation, Metal Clips	0.11	0.09	0.09	0.11				
R-6 Exterior Insulation	0.12	0.10	0.10	0.12				
R-10 Exterior Insulation	0.08	0.07	0.07	0.08				
R-9.5 Rigid Polystyrene Integral Insulation, Two Webbed Block	0.11	0.09	0.09	0.12				

12" Concrete Masonry

	CORE TREATMENT			
	Partial G	Partial Grout with Ungrouted Cores		
		Loose-fill insulated		
Wall Description	Empty	Perlite	Vermiculite	Solid Grout
Exposed Block, Both Sides	0.35	0.17	0.18	0.33
R-5 Interior Insulation, Wood Furring	0.14	0.10	0.10	0.13
R-6 Interior Insulation, Wood Furring	0.13	0.09	0.10	0.13
R-10.5 Interior Insulation, Wood Furring	0.11	0.08	0.08	0.10

	CORE TREATMENT			
	Partial G	Partial Grout with Ungrouted Cores		
		Loose-fill insulated		
Wall Description	Empty	Perlite	Vermiculite	Solid Grout
R-8 Interior Insulation, Metal Clips	0.10	0.08	0.08	0.09
R-6 Exterior Insulation	0.11	0.09	0.09	0.11
R-10 Exterior Insulation	0.08	0.06	0.06	0.08
R-9.5 Rigid Polystyrene Integral Insulation, Two Webbed Block	0.11	0.08	0.09	0.12

8" Clay Brick

	CORE TREATMENT			
	Partial G	rout with Ungro	outed Cores	
		Loose-fil	l insulated	
Wall Description	Empty	Perlite	Vermiculite	Solid Grout
Exposed Block, Both Sides	0.50	0.31	0.32	0.56
R-5 Interior Insulation, Wood Furring	0.15	0.13	0.13	0.16
R-6 Interior Insulation, Wood Furring	0.15	0.12	0.12	0.15
R-10.5 Interior Insulation, Wood Furring	0.12	0.10	0.10	0.12
R-8 Interior Insulation, Metal Clips	0.11	0.10	0.10	0.11
R-6 Exterior Insulation	0.12	0.11	0.11	0.13
R-10 Exterior Insulation	0.08	0.08	0.08	0.09

6" Concrete Poured or Precast

	CORE TREATMENT			
	Partial G	rout with Ungr	outed Cores	
		Loose-fi	ll insulated	
Wall Description	Empty	Perlite	Vermiculite	Solid Grout
Exposed Concrete, Both Sides	NA	NA	NA	0.61
R-5 Interior Insulation, Wood Furring	NA	NA	NA	0.16
R-6 Interior Insulation, Wood Furring	NA	NA	NA	0.15
R-10.5 Interior Insulation, Wood Furring	NA	NA	NA	0.12
R-8 Interior Insulation, Metal Clips	NA	NA	NA	0.12
R-6 Exterior Insulation	NA	NA	NA	0.13
R-10 Exterior Insulation	NA	NA	NA	0.09

- 1. Grouted cores at 40" \times 48" on center vertically and horizontally in partial grouted walls.
- 2. Interior insulation values include 1/2" gypsum board on the inner surface.
- 3. Furring and stud spacing is 16" on center. Insulation is assumed to fill furring space and is not compressed.
- 4. Intermediate values may be interpolated using this table. Values not contained in this table may be computed using the procedures listed in the ASHRAE Fundamentals Handbook.
- 5. Concrete Masonry Unit (CMU) assembly U-values are based on local test data for Washington state CMU block material using the ASTM C-236-87 steady state thermal conductance test. Tests

included an 8"x8"x16" CMU with all cells filled with vermiculite (1995) and 8"x8"x16" CMU with all cells filled with polymaster foam in place insulation (1996). Refer to ASHRAE Standard 90.1 for additional nationally recognized data on the thermal performance of CMU block walls.

Table A103.3.7.1(2) Default U-Factors for Concrete and Masonry Wallsa, b, c, d

Framing Type and Depth	Rated R-value of Insulation Alone	Assembly U- factors for Solid Concrete Walls	Assembly U- factors for Concrete Block Walls: Solid Grouted	Assembly U- factors for Concrete Block Walls: Partially Grouted (Cores Uninsulated Except Where Specified)
Base Wall only	T			
No Framing	R-0	U-0.740	U-0.580	U-0.480
	Ungrouted Cores Filled with Loose- Fill Insulation	N.A.	N.A.	U-0.350
Continuous Wood Fra	aming			
0.75 in.	R-3.0	U-0.247	U-0.226	U-0.210
1.5 in.	R-6.0	U-0.160	U-0.151	U-0.143
2.0 in.	R-10.0	U-0.116	U-0.111	U-0.107
3.5 in.	R-11.0	U-0.094	U-0.091	U-0.088
3.5 in.	R-13.0	U-0.085	U-0.083	U-0.080
3.5 in.	R-15.0	U-0.079	U-0.077	U-0.075
5.5 in.	R-19.0	U-0.060	U-0.059	U-0.058
5.5 in.	R-21.0	U-0.057	U-0.055	U-0.054
Continuous Metal Fra	aming at 24 in. on cente	r horizontally		
1.0 in.	R-0.0	U-0.414	U-0.359	U-0.318
1.0 in.	R-3.8	U-0.325	U-0.290	U-0.263
1.0 in.	R-5.0	U-0.314	U-0.281	U-0.255
1.0 in.	R-6.5	U-0.305	U-0.274	U-0.249
1.5 in.	R-11.0	U-0.267	U-0.243	U-0.223
2.0 in.	R-7.6	U-0.230	U-0.212	U-0.197
2.0 in.	R-10.0	U-0.219	U-0.202	U-0.188
2.0 in.	R-13.0	U-0.210	U-0.195	U-0.182
3.0 in.	R-11.4	U-0.178	U-0.167	U-0.157
3.0 in.	R-15.0	U-0.168	U-0.158	U-0.149
3.0 in.	R-19.0	U-0.161	U-0.152	U-0.144
3.5 in.	R-11.0	U-0.168	U-0.158	U-0.149
3.5 in.	R-13.0	U-0.161	U-0.152	U-0.144
3.5 in.	R-15.0	U-0.155	U-0.147	U-0.140
4.5 in.	R-17.1	U-0.133	U-0.126	U-0.121
4.5 in.	R-22.5	U-0.124	U-0.119	U-0.114

Framing Type and Depth	Rated R-value of Insulation Alone	Assembly U- factors for Solid Concrete Walls	Assembly U- factors for Concrete Block Walls: Solid Grouted	Assembly U- factors for Concrete Block Walls: Partially Grouted (Cores Uninsulated Except Where Specified)
4.5 in.	R-25.2	U-0.122	U-0.116	U-0.112
5.0 in.	R-19.0	U-0.122	U-0.117	U-0.112
5.0 in.	R-25.0	U-0.115	U-0.110	U-0.106
5.0 in.	R-28.0	U-0.112	U-0.107	U-0.103
5.0 in.	R-32.0	U-0.109	U-0.105	U-0.101
5.5 in.	R-19.0	U-0.118	U-0.113	U-0.109
5.5 in.	R-20.9	U-0.114	U-0.109	U-0.105
5.5 in.	R-21.0	U-0.113	U-0.109	U-0.105
5.5 in.	R-27.5	U-0.106	U-0.102	U-0.099
5.5 in.	R-30.8	U-0.104	U-0.100	U-0.096
6.0 in.	R-22.8	U-0.106	U-0.102	U-0.098
6.0 in.	R-30.0	U-0.099	U-0.095	U-0.092
6.0 in.	R-33.6	U-0.096	U-0.093	U-0.090
6.5 in.	R-24.7	U-0.099	U-0.096	U-0.092
7.0 in.	R-26.6	U-0.093	U-0.090	U-0.087
7.5 in. 8.0 in.	R-28.5 R-30.4	U-0.088 U-0.083	U-0.085 U-0.081	U-0.083 U-0.079
for assemblies with a	ratio of metal penetration for determination of the real for determination of the real for the real for the real forms of the real forms o	ally and 16 in. vertically on area/mass wall area mination of U-factors fo	of < 0.0004 or $< 0.04\%$	of the mass wall
1.0 in.	R-3.8	U-0.210	U-0.195	U-0.182
1.0 in.	R-5.0	U-0.184	U-0.172	U-0.162
1.0 in.	R-5.6	U-0.174	U-0.163	U-0.154
1.5 in.	R-5.7	U-0.160	U-0.151	U-0.143
1.5 in.	R-7.5	U-0.138	U-0.131	U-0.125
1.5 in.	R-8.4	U-0.129	U-0.123	U-0.118
2.0 in.	R-7.6	U-0.129	U-0.123	U-0.118
2.0 in.	R-10.0	U-0.110	U-0.106	U-0.102
2.0 in.	R-11.2	U-0.103	U-0.099	U-0.096
2.5 in.	R-9.5	U-0.109	U-0.104	U-0.101
2.5 in.	R-12.5	U-0.092	U-0.089	U-0.086
2.5 in.	R-14.0	U-0.086	U-0.083	U-0.080
3.0 in.	R-11.4	U-0.094	U-0.090	U-0.088
3.0 in.	R-15.0	U-0.078	U-0.076	U-0.074
3.0 in.	R-16.8	U-0.073	U-0.071	U-0.069
3.5 in.	R-13.3	U-0.082	U-0.080	U-0.077
3.5 in. 3.5 in.	R-17.5	U-0.069	U-0.067	U-0.065
	R-19.6	U-0.064	U-0.062	U-0.061
4.0 in.	R-15.2	U-0.073	U-0.071	U-0.070

Framing Type and Depth Rated R-value of Insulation Alone Assembly Ufactors for Solid Concrete Block Walls: Partially Grouted (Corese Uninsulated Except Where Specified) 4.0 in. R-20.0 U-0.061 U-0.060 U-0.058 4.0 in. R-22.4 U-0.057 U-0.056 U-0.044 5.0 in. R-32.6 U-0.039 U-0.039 U-0.039 6.0 in. R-33.6 U-0.039 U-0.039 U-0.038 7.0 in. R-39.2 U-0.034 U-0.039 U-0.038 8.0 in. R-44.8 U-0.002 U-0.027 U-0.026 9.0 in. R-56.0 U-0.022 U-0.027 U-0.026 10 in. R-56.0 U-0.022 U-0.022 U-0.022 10 in. R-56.0 U-0.022 U-0.266 U-0.245 11 in. R-61.0 U-0.230 <td< th=""><th></th><th></th><th></th><th></th><th>Assembly U-</th></td<>					Assembly U-
Framing Type and Depth Rated R-value of Insulation Alone Language of Rate (Partially factors for Solid Concrete Block Walls: Partially factors for Solid Concrete Walls Longonia (Partially factors for Solid Concrete Walls) Longonia (Partially factors for Solid Grouted) Long					· ·
Framing Type and Dopth Rated R-value of Insulation Alone Assembly U- Factors For Solid Concrete Block Walls: Solid Specified) Concrete Block Walls: Solid Grouted Specified) Concrete Block Walls: Solid Grouted Specified) Concrete Walls U-0.066 U-0.058 4.0 in. R-22.4 U-0.057 U-0.056 U-0.054 5.0 in. R-28.0 U-0.039 U-0.039 U-0.038 7.0 in. R-33.6 U-0.039 U-0.039 U-0.038 8.0 in. R-44.8 U-0.030 U-0.030 U-0.029 9.0 in. R-56.0 U-0.027 U-0.022 U-0.026 10 in. R-56.0 U-0.022 U-0.022 U-0.022 11 in. R-61.6 U-0.022 U-0.022 U-0.022 No Framing R-1.0 U-0.425 U-0.022 U-0.022 No Framing R-1.0 U-0.289 U-0.299 U-0.245 No Framing R-6.0 U-0.187 U-0.175 U-0.164 No Framing R-6.0 U-0.180 U-0.129 U-0.124 No Framing R-1.0 <th></th> <th></th> <th></th> <th></th> <th></th>					
Framing Type and Depth Rated R-value for Depth Assembly U-factors for Solid Concrete Walls Concrete Block Walls: Solid Concrete Walls Un.0058 4.0 in. R-20.0 U-0.061 U-0.066 U-0.058 5.0 in. R-22.4 U-0.037 U-0.036 U-0.045 6.0 in. R-33.6 U-0.039 U-0.039 U-0.038 7.0 in. R-39.2 U-0.034 U-0.034 U-0.033 8.0 in. R-44.8 U-0.029 U-0.027 U-0.026 9.0 in. R-50.4 U-0.022 U-0.022 U-0.024 10 in. R-56.6 U-0.022 U-0.022 U-0.022 10 in. R-56.6 U-0.022 U-0.022 U-0.022 11 in. R-61.6 U-0.022 U-0.022 U-0.022 15 in. R-56.0 U-0.288 U-0.267 U-0.245 16 in. U-0.242 U-0.367 U-0.245 17 in. R-6.0 U-0.189 U-0.175 U-0.141 No Framing R-6.0 U-0.120 U-0.18				Assembly U-	·
Framing Type and pepth Rated R-value of Insulation Alon Concrete Walls Walls: Solid of Concrete Walls Except Where Specified) 4.0 in. R-20.0 U-0.061 U-0.066 U-0.054 4.0 in. R-22.4 U-0.057 U-0.056 U-0.054 5.0 in. R-28.0 U-0.039 U-0.039 U-0.038 7.0 in. R-39.2 U-0.030 U-0.030 U-0.029 8.0 in. R-44.8 U-0.027 U-0.027 U-0.026 10 in. R-50.4 U-0.022 U-0.022 U-0.026 10 in. R-50.6 U-0.022 U-0.022 U-0.026 11 in. R-61.6 U-0.022 U-0.022 U-0.026 11 in. R-61.6 U-0.022 U-0.022 U-0.024 11 in. R-61.6 U-0.022 U-0.022 U-0.024 11 in. R-61.6 U-0.022 U-0.026 U-0.024 11 in. R-61.6 U-0.228 U-0.269 U-0.245 12 in. R-2.0 U-0.157 U-0.119 <th></th> <th></th> <th></th> <th></th> <th>`</th>					`
Depth Insulation Alone Concrete Walls Grouted Specified) 4.0 in. R-20.0 U-0.061 U-0.056 U-0.054 5.0 in. R-22.80 U-0.046 U-0.046 U-0.045 6.0 in. R-33.6 U-0.039 U-0.039 U-0.038 7.0 in. R-33.6 U-0.034 U-0.030 U-0.032 8.0 in. R-44.8 U-0.030 U-0.029 U-0.029 9.0 in. R-50.4 U-0.024 U-0.024 U-0.024 10 in. R-56.0 U-0.022 U-0.022 U-0.024 11 in. R-61.6 U-0.022 U-0.022 U-0.024 11 in. R-61.6 U-0.022 U-0.022 U-0.024 No Framing R-1.0 U-0.228 U-0.022 U-0.224 No Framing R-1.0 U-0.298 U-0.269 U-0.144 No Framing R-2.0 U-0.187 U-0.115 U-0.144 No Framing R-6.0 U-0.136 U-0.129 U-0.124	Framing Type and	Doted D volue of			
4.0 in. R-20.0 U-0.061 U-0.060 U-0.058 4.0 in. R-22.4 U-0.057 U-0.056 U-0.054 5.0 in. R-28.0 U-0.046 U-0.046 U-0.045 6.0 in. R-33.6 U-0.039 U-0.039 U-0.038 7.0 in. R-33.6 U-0.034 U-0.034 U-0.033 7.0 in. R-39.2 U-0.034 U-0.030 U-0.039 9.0 in. R-44.8 U-0.030 U-0.030 U-0.029 9.0 in. R-50.4 U-0.027 U-0.027 U-0.026 10 in. R-55.0 U-0.024 U-0.024 U-0.024 11 in. R-61.6 U-0.022 U-0.022 U-0.022 12 in. R-61.6 U-0.022 U-0.022 U-0.022 13 in. R-20.0 U-0.258 U-0.269 U-0.245 R-2.0 U-0.298 U-0.269 U-0.245 R-3.0 U-0.187 U-0.175 U-0.164 R-4.0 U-0.187 U-0.175 U-0.164 R-5.0 U-0.157 U-0.149 U-0.141 No Framing R-6.0 U-0.156 U-0.115 U-0.110 R-8.0 U-0.107 U-0.103 U-0.099 R-10.0 U-0.097 U-0.093 U-0.099 R-10.0 U-0.097 U-0.093 U-0.099 R-10.0 U-0.081 U-0.095 U-0.083 No Framing R-11.0 U-0.081 U-0.079 U-0.076 R-13.0 U-0.075 U-0.073 U-0.071 R-13.0 U-0.070 U-0.068 U-0.066 R-14.0 U-0.065 U-0.064 U-0.069 R-15.0 U-0.054 U-0.055 U-0.059 No Framing R-16.0 U-0.058 U-0.056 U-0.059 No Framing R-16.0 U-0.054 U-0.054 U-0.059 No Framing R-16.0 U-0.054 U-0.056 U-0.050 R-19.0 U-0.047 U-0.046 U-0.050 R-20.0 U-0.047 U-0.046 U-0.047 R-20.0 U-0.047 U-0.046 U-0.047 R-20.0 U-0.047 U-0.046 U-0.047 R-20.0 U-0.047 U-0.046 U-0.047 R-23.0 U-0.047 U-0.046 U-0.047 R-24.0 U-0.049 U-0.042 U-0.042 R-23.0 U-0.049 U-0.042 U-0.042 R-24.0 U-0.039 U-0.039 U-0.037 No Framing R-35.0 U-0.032 U-0.032 U-0.037 No Framing R-35.0 U-0.032 U-0.032 U-0.037 No Framing R-35.0 U-0.032 U-0.032					_
4.0 in. R-22.4 U-0.057 U-0.056 U-0.045 5.0 in. R-28.0 U-0.046 U-0.039 U-0.038 6.0 in. R-33.6 U-0.039 U-0.034 U-0.033 8.0 in. R-44.8 U-0.030 U-0.020 U-0.029 9.0 in. R-50.4 U-0.027 U-0.024 U-0.026 10 in. R-56.0 U-0.024 U-0.024 U-0.024 11 in. R-61.6 U-0.022 U-0.022 U-0.022 Continuous Insulation Uninterrupted by Framing No Framing R-1.0 U-0.425 U-0.367 U-0.324 R-2.0 U-0.298 U-0.269 U-0.245 R-3.0 U-0.187 U-0.175 U-0.197 R-4.0 U-0.187 U-0.175 U-0.144 No Framing R-6.0 U-0.187 U-0.193 U-0.194 R-7.0 U-0.120 U-0.115 U-0.114 No Framing R-10.0 U-0.081 U-0.093 U-0.090 R-10.0	•		1	<u>L</u>	•
5.0 in. R-28.0 U-0.046 U-0.046 U-0.045 6.0 in. R-33.6 U-0.039 U-0.039 U-0.038 7.0 in. R-39.2 U-0.034 U-0.034 U-0.033 8.0 in. R-44.8 U-0.027 U-0.027 U-0.026 10 in. R-56.0 U-0.024 U-0.024 U-0.024 11 in. R-61.6 U-0.022 U-0.022 U-0.022 Continuous Insulation Uninterrupted by Framing No Framing R-1.0 U-0.425 U-0.367 U-0.324 No Framing R-1.0 U-0.425 U-0.367 U-0.324 R-2.0 U-0.298 U-0.269 U-0.245 R-3.0 U-0.230 U-0.122 U-0.197 R-3.0 U-0.187 U-0.175 U-0.164 R-5.0 U-0.187 U-0.175 U-0.164 No Framing R-6.0 U-0.136 U-0.129 U-0.124 R-7.0 U-0.107 U-0.103 U-0.091 R-8.0 U-0.107 U-0.033 U-0.061 <td>4.0 in.</td> <td>R-22.4</td> <td>U-0.057</td> <td>U-0.056</td> <td>U-0.054</td>	4.0 in.	R-22.4	U-0.057	U-0.056	U-0.054
7.0 in. R-39.2 U-0.034 U-0.030 U-0.029 8.0 in. R-44.8 U-0.030 U-0.027 U-0.026 9.0 in. R-50.4 U-0.024 U-0.027 U-0.024 10 in. R-56.0 U-0.024 U-0.022 U-0.022 11 in. R-61.6 U-0.022 U-0.022 U-0.022 Continuous Insulation Uninterrupted by Framing W U-0.367 U-0.324 No Framing R-1.0 U-0.425 U-0.3667 U-0.324 R-3.0 U-0.298 U-0.269 U-0.455 R-3.0 U-0.230 U-0.219 U-0.197 R-4.0 U-0.187 U-0.175 U-0.164 R-5.0 U-0.187 U-0.175 U-0.164 R-5.0 U-0.157 U-0.149 U-0.141 No Framing R-6.0 U-0.156 U-0.115 U-0.110 R-8.0 U-0.107 U-0.033 U-0.099 R-9.0 U-0.097 U-0.093 U-0.081 No Framing R-	5.0 in.	R-28.0	U-0.046	U-0.046	U-0.045
8.0 in.	6.0 in.	R-33.6	U-0.039	U-0.039	U-0.038
9.0 in.	7.0 in.	R-39.2	U-0.034	U-0.034	U-0.033
10 in.	8.0 in.	R-44.8	U-0.030	U-0.030	U-0.029
To the continuous Insulation Uninterrupted by Framing R-1.0 U-0.425 U-0.026 U-0.245 R-2.0 U-0.298 U-0.269 U-0.245 R-3.0 U-0.230 U-0.212 U-0.197 R-4.0 U-0.187 U-0.175 U-0.164 U-0.175 U-0.144 U-0.175 U-0.144 U-0.175 U-0.144 U-0.175 U-0.144 U-0.175 U-0.144 U-0.144 U-0.175 U-0.144 U-0.175 U-0.144 U-0.144 U-0.175 U-0.110 R-5.0 U-0.120 U-0.115 U-0.110 U-0.110 R-8.0 U-0.107 U-0.103 U-0.099 R-9.0 U-0.097 U-0.093 U-0.099 R-9.0 U-0.097 U-0.093 U-0.090 U-0.088 U-0.085 U-0.083 U-0.083 U-0.085 U-0.083 U-0.096 R-12.0 U-0.075 U-0.073 U-0.071 R-13.0 U-0.075 U-0.073 U-0.071 R-13.0 U-0.065 U-0.064 U-0.062 U-0.066 R-14.0 U-0.065 U-0.064 U-0.062 R-15.0 U-0.061 U-0.060 U-0.059 U-0.055 R-17.0 U-0.054 U-0.056 U-0.055 R-18.0 U-0.054 U-0.055 U-0.055 R-18.0 U-0.052 U-0.051 U-0.055 R-19.0 U-0.049 U-0.048 U-0.047 U-0.045 U-0.047 R-20.0 U-0.047 U-0.048 U-0.045 U-0.046 U-	9.0 in.	R-50.4	U-0.027	U-0.027	U-0.026
No Framing R-1.0	10 in.	R-56.0	U-0.024	U-0.024	U-0.024
No Framing R-1.0	11 in.	R-61.6	U-0.022	U-0.022	U-0.022
R-2.0	Continuous Insulation	n Uninterrupted by Fran	ning		
R-3.0	No Framing	R-1.0	U-0.425	U-0.367	U-0.324
R-4.0		R-2.0	U-0.298	U-0.269	U-0.245
R-5.0		R-3.0	U-0.230	U-0.212	U-0.197
No Framing R-6.0		R-4.0	U-0.187	U-0.175	U-0.164
R-7.0 U-0.120 U-0.115 U-0.110 R-8.0 U-0.107 U-0.103 U-0.099 R-9.0 U-0.097 U-0.093 U-0.090 R-10.0 U-0.088 U-0.085 U-0.083 No Framing R-11.0 U-0.081 U-0.079 U-0.076 R-12.0 U-0.075 U-0.073 U-0.071 R-13.0 U-0.070 U-0.068 U-0.066 R-14.0 U-0.065 U-0.064 U-0.062 R-15.0 U-0.061 U-0.060 U-0.059 No Framing R-16.0 U-0.058 U-0.056 U-0.055 R-17.0 U-0.054 U-0.053 U-0.052 R-18.0 U-0.052 U-0.051 U-0.050 R-19.0 U-0.049 U-0.048 U-0.047 R-20.0 U-0.047 U-0.048 U-0.045 No Framing R-21.0 U-0.045 U-0.044 U-0.045 No Framing R-22.0 U-0.043 U-0.044 U-0.043 R-23.0 U-0.041 U-0.040 U-0.042 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.028 U-0.027 U-0.027		R-5.0	U-0.157	U-0.149	U-0.141
R-8.0	No Framing	R-6.0	U-0.136	U-0.129	U-0.124
R-9.0		R-7.0	U-0.120	U-0.115	U-0.110
R-10.0		R-8.0	U-0.107	U-0.103	U-0.099
No Framing R-11.0 U-0.081 U-0.079 U-0.076 R-12.0 U-0.075 U-0.073 U-0.071 R-13.0 U-0.070 U-0.068 U-0.066 R-14.0 U-0.065 U-0.064 U-0.062 R-15.0 U-0.061 U-0.060 U-0.059 No Framing R-16.0 U-0.058 U-0.056 U-0.055 R-17.0 U-0.054 U-0.053 U-0.052 R-18.0 U-0.052 U-0.051 U-0.050 R-19.0 U-0.049 U-0.048 U-0.047 R-20.0 U-0.047 U-0.046 U-0.045 No Framing R-21.0 U-0.045 U-0.044 U-0.045 No Framing R-22.0 U-0.043 U-0.042 U-0.042 R-23.0 U-0.041 U-0.040 U-0.042 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024		R-9.0	U-0.097	U-0.093	U-0.090
R-12.0 U-0.075 U-0.073 U-0.071 R-13.0 U-0.070 U-0.068 U-0.066 R-14.0 U-0.065 U-0.064 U-0.062 R-15.0 U-0.061 U-0.060 U-0.059 No Framing R-16.0 U-0.058 U-0.056 U-0.055 R-17.0 U-0.054 U-0.053 U-0.052 R-18.0 U-0.052 U-0.051 U-0.050 R-19.0 U-0.049 U-0.048 U-0.047 R-20.0 U-0.047 U-0.046 U-0.045 No Framing R-21.0 U-0.045 U-0.044 U-0.043 R-22.0 U-0.043 U-0.042 U-0.043 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024		R-10.0	U-0.088	U-0.085	U-0.083
R-13.0 U-0.070 U-0.068 U-0.066 R-14.0 U-0.065 U-0.064 U-0.062 R-15.0 U-0.061 U-0.060 U-0.059 No Framing R-16.0 U-0.058 U-0.056 U-0.055 R-17.0 U-0.054 U-0.053 U-0.052 R-18.0 U-0.052 U-0.051 U-0.050 R-19.0 U-0.049 U-0.048 U-0.047 R-20.0 U-0.047 U-0.046 U-0.045 No Framing R-21.0 U-0.045 U-0.044 U-0.043 R-22.0 U-0.043 U-0.042 U-0.042 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.028 U-0.027 R-40.0 U-0.024 U-0.024	No Framing	R-11.0	U-0.081	U-0.079	U-0.076
R-14.0		R-12.0	U-0.075	U-0.073	U-0.071
R-15.0 U-0.061 U-0.060 U-0.059 No Framing R-16.0 U-0.058 U-0.056 U-0.055 R-17.0 U-0.054 U-0.053 U-0.052 R-18.0 U-0.052 U-0.051 U-0.050 R-19.0 U-0.049 U-0.048 U-0.047 R-20.0 U-0.047 U-0.046 U-0.045 No Framing R-21.0 U-0.045 U-0.044 U-0.043 R-22.0 U-0.043 U-0.042 U-0.042 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024		R-13.0	U-0.070	U-0.068	U-0.066
No Framing R-16.0 U-0.058 U-0.056 U-0.055 R-17.0 U-0.054 U-0.053 U-0.052 R-18.0 U-0.052 U-0.051 U-0.050 R-19.0 U-0.049 U-0.048 U-0.047 R-20.0 U-0.047 U-0.046 U-0.045 No Framing R-21.0 U-0.045 U-0.044 U-0.043 R-22.0 U-0.043 U-0.042 U-0.042 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024		R-14.0	U-0.065	U-0.064	U-0.062
R-17.0 U-0.054 U-0.053 U-0.052 R-18.0 U-0.052 U-0.051 U-0.050 R-19.0 U-0.049 U-0.048 U-0.047 R-20.0 U-0.047 U-0.046 U-0.045 No Framing R-21.0 U-0.045 U-0.044 U-0.043 R-22.0 U-0.043 U-0.042 U-0.042 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024		R-15.0	U-0.061	U-0.060	U-0.059
R-18.0 U-0.052 U-0.051 U-0.050 R-19.0 U-0.049 U-0.048 U-0.047 R-20.0 U-0.047 U-0.046 U-0.045 No Framing R-21.0 U-0.045 U-0.044 U-0.043 R-22.0 U-0.043 U-0.042 U-0.042 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024	No Framing	R-16.0	U-0.058	U-0.056	U-0.055
R-19.0 U-0.049 U-0.048 U-0.047 R-20.0 U-0.047 U-0.046 U-0.045 No Framing R-21.0 U-0.045 U-0.044 U-0.043 R-22.0 U-0.043 U-0.042 U-0.042 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024		R-17.0	U-0.054	U-0.053	U-0.052
R-20.0 U-0.047 U-0.046 U-0.045 No Framing R-21.0 U-0.045 U-0.044 U-0.043 R-22.0 U-0.043 U-0.042 U-0.042 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024		R-18.0	U-0.052	U-0.051	U-0.050
No Framing R-21.0 U-0.045 U-0.044 U-0.043 R-22.0 U-0.043 U-0.042 U-0.042 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024		R-19.0	U-0.049	U-0.048	U-0.047
R-22.0 U-0.043 U-0.042 U-0.042 R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024		R-20.0	U-0.047	U-0.046	U-0.045
R-23.0 U-0.041 U-0.040 U-0.040 R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024	No Framing	R-21.0	U-0.045	U-0.044	U-0.043
R-24.0 U-0.039 U-0.039 U-0.038 R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024		R-22.0	U-0.043	U-0.042	U-0.042
R-25.0 U-0.038 U-0.037 U-0.037 No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024		R-23.0	U-0.041	U-0.040	U-0.040
No Framing R-30.0 U-0.032 U-0.032 U-0.031 R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024		R-24.0	U-0.039	U-0.039	U-0.038
R-35.0 U-0.028 U-0.027 U-0.027 R-40.0 U-0.024 U-0.024 U-0.024		R-25.0	U-0.038	U-0.037	U-0.037
R-40.0 U-0.024 U-0.024 U-0.024	No Framing	R-30.0	U-0.032	U-0.032	U-0.031
		R-35.0	U-0.028	U-0.027	U-0.027
D 45.0		R-40.0	U-0.024	U-0.024	U-0.024
R-45.0 U-0.022 U-0.021 U-0.021		R-45.0	U-0.022	U-0.021	U-0.021

			T	
				Assembly U- factors for
				Concrete Block
			Assembly U-	Walls: Partially
			factors for	Grouted (Cores
		Assembly U-	Concrete Block	Uninsulated
Framing Type and	Rated R-value of	factors for Solid	Walls: Solid	Except Where
Depth	Insulation Alone	Concrete Walls	Grouted	Specified)
	R-50.0	U-0.019	U-0.019	U-0.019
	R-55.0	U-0.018	U-0.018	U-0.018
	R-60.0	U-0.016	U-0.016	U-0.016
·	th continuous insulation	Ī	T	ī
No Framing	R-0.0	U-0.337	U-0.299	U-0.270
No Framing	R-3.8	U-0.148	U-0.140	U-0.133
No Framing	R-5.0	U-0.125	U-0.120	U-0.115
No Framing	R-6.5	U-0.106	U-0.102	U-0.098
No Framing	R-7.6	U-0.095	U-0.091	U-0.088
No Framing	R-10.0	U-0.077	U-0.075	U-0.073
No Framing	R-10.5	U-0.079	U-0.077	U-0.075
No Framing	R-11.4	U-0.070	U-0.068	U-0.066
No Framing	R-15.0	U-0.056	U-0.055	U-0.053
No Framing	R-16.5	U-0.054	U-0.053	U-0.052
No Framing	R-19.0	U-0.046	U-0.045	U-0.044
No Framing	R-22.5	U-0.041	U-0.040	U-0.039
No Framing	R-28.5	U-0.033	U-0.032	U-0.032
Continuous Insulation horizontally	uninterrupted by Fran	ning with Stucco and Co	ontinuous Metal Framii	ng at 24 in. on center
1.0 in.	R-0.0 + R-19 c.i.	U-0.047	U-0.046	U-0.045
1.0 in.	R-3.8 + R-19 c.i.	U-0.045	U-0.044	U-0.044
1.0 in.	R-5.0 + R-19 c.i.	U-0.045	U-0.044	U-0.043
1.0 in.	R-6.5 + R-19 c.i.	U-0.045	U-0.044	U-0.043
1.5 in.	R-11.0 + R-19 c.i.	U-0.044	U-0.043	U-0.043
2.0 in.	R-7.6 + R-19 c.i.	U-0.043	U-0.042	U-0.041
2.0 in.	R-10.0 + R-19 c.i.	U-0.042	U-0.041	U-0.041
2.0 in.	R-13.0 + R-19 c.i.	U-0.042	U-0.041	U-0.041
3.0 in.	R-11.4 + R-19 c.i.	U-0.041	U-0.040	U-0.039
3.0 in.	R-15.0 + R-19 c.i.	U-0.040	U-0.039	U-0.039
3.0 in.	R-19.0 + R-19 c.i.	U-0.040	U-0.039	U-0.038
3.5 in.	R-11.0 + R-19 c.i.	U-0.040	U-0.039	U-0.039
3.5 in.	R-13.0 + R-19 c.i.	U-0.040	U-0.039	U-0.038
5.0 in.	R-19.0 + R-19 c.i.	U-0.037	U-0.036	U-0.036
5.0 in.	R-25.0 + R-19 c.i.	U-0.036	U-0.035	U-0.035
5.0 in.	R-32.5 + R-19 c.i.	U-0.035	U-0.035	U-0.034
5.5 in.	R-19.0 + R-19 c.i.	U-0.036	U-0.036	U-0.035
5.5 in.	R-21.0 + R-19 c.i.	U-0.035	U-0.035	U-0.035
5.5 m.	11 21.0 1 10 17 0.1.	2 0.022	0.000	0.000

Note for Default Table A103.3.7.1(2):

a. It is acceptable to use the U-factors in Table A103.3.7.1(2) for all concrete and masonry walls, provided that the grouting is equal to or less than that specified.

- -For ungrouted walls, use the partially grouted column.
- -For metal studs and z-furring, use the continuous-metal-framing category.
- -For discontinuous metal clips 1 inch square or smaller, use the metal-clip category.
- -For insulation that is attached without any framing members (e.g. glued), use the continuous-insulation uninterrupted-by-framing category. Continuous insulation may be installed on the interior or exterior of masonry walls, or between stand-alone walls in multilayer masonry walls, or on the interior or exterior of the concrete.
- b. For Table A103.3.7.1(2), the U-factor includes R-0.17 for exterior air film and R-0.68 for interior air film-vertical surfaces. For insulated walls, the U-factor also includes R-0.45 for 0.5 in. gypsum board. U-factors are provided for the following configurations:
 - (1) Concrete wall: 8-in. normal weight concrete wall with a density of 145 lb/ft³.
 - (2) Solid grouted concrete block wall: 8-in. medium weight ASTM C90 concrete block with a density of 115 lb/ft³ and solid grouted cores.
 - (3) Partially grouted concrete block wall: 8-in. medium weight ASTM C90 concrete block with a density of 115 lb/ft³ having reinforcing steel every 32 in. vertically and every 48 in. horizontally, with cores grouted in those areas only. Other cores are filled with insulating material only if there is no other insulation.
- c. For walls with insulation contained in a framing layer, the U-factors in Table A103.3.7.1(2) assume contact (and thermal bridging) between the mass wall and other framing. For wall assemblies with multiple layers where the wood or metal framing layer does not contact the concrete or masonry layer (i.e., walls with an airspace between the stud wall layer and the mass wall layer), it is acceptable to use the appropriate wood or metal frame wall default U-factors in Tables A103.3.1 or A103.3.6.1. Note: It is acceptable to use this approach where the insulation extends beyond the framing and is in contact with the mass wall layer (e.g. a nominal four-inch metal stud containing insulation that is nominally six inches thick and therefore extends two inches beyond the back of the metal stud).
- d. Except for wall assemblies qualifying for note 3, if not taken from Table A103.3.7.1(2), mass wall U-factors shall be determined in accordance with ASHRAE 90.1, Appendix A, Section A3.1 and Tables A3.1A to A3.1D, or Section A9.4.

A103.3.7.2 Peripheral edges of intermediate concrete floors. See Table A103.3.7.2.

Table A103.3.7.2

Default U-factors for Peripheral Edges of Intermediate Concrete Floors a, b, c, d

	Av	Average Thickness of Wall above and below			
Slab Edge Treatment	6 inches	8 inches	10 inches	12 inches	
Exposed Concrete	0.816	0.741	0.678	0.625	
R-5 Exterior Insulation	0.161	0.157	0.154	0.152	
R-6 Exterior Insulation	0.138	0.136	0.134	0.132	
R-7 Exterior Insulation	0.122	0.120	0.118	0.116	
R-8 Exterior Insulation	0.108	0.107	0.106	0.104	
R-9 Exterior Insulation	0.098	0.097	0.095	0.094	
R-10 Exterior Insulation	0.089	0.088	0.087	0.086	
R-11 Exterior Insulation	0.082	0.081	0.080	0.079	
R-12 Exterior Insulation	0.076	0.075	0.074	0.074	
R-13 Exterior Insulation	0.070	0.070	0.069	0.068	
R-14 Exterior Insulation	0.066	0.065	0.065	0.064	
R-15 Exterior Insulation	0.062	0.061	0.061	0.060	

Note for Table A103.3.7.2:

- a. Exterior insulation values listed above are continuous R-values on the exterior side of the concrete floor.
- b. For conditions with an exterior wall above the peripheral edge of intermediate concrete floor but with no wall below the intermediate concrete floor this table may be used as long as the code minimum insulation is applied to the floor slab below the concrete floor.
- c. Typical conditions where conditioned space building envelope wall thermal insulation values are broken concrete floors include, but are not limited to, the following examples:
 - 1. Elevator hoistway shafts that serve the conditioned building and pass through unconditioned floors such as parking garage levels;
 - 2. Stairwell enclosures that serve the conditioned building and pass through unconditioned floors such as parking garage levels;
 - 3. Walls between interior and exterior building envelope that separate the interior conditioned space from an exterior courtyard or roofdeck;
 - 4. Walls between interior and exterior building envelope that separate the interior conditioned space from an exterior unconditioned space on parking garage levels.

WAC 51-11C-61040 Section A104--Below-grade walls and slabs.

NEW SECTION

WAC 51-11C-61041 Section A104.1--General.

A104.1 General. Table A104.1 lists heat loss coefficients for below-grade walls and floors.

Coefficients for below-grade walls are given as U-factors (Btu/h \bullet ft² \bullet °F of wall area). Coefficients for below-grade slabs are listed as F-factors (Btu/h \bullet ft \bullet °F per lineal foot of slab perimeter).

Below-grade wall U-factors are only valid when used with the accompanying below-grade slab F-factor, and vice versa.

Table A104.1
Default Wall U-factors and Slab F-factors for Basements

	Below Grade Wall U-factor	Below Grade Slab F-factor
2 Foot Depth Below	Grade	
Uninsulated	0.350	0.59
R-11 Interior	0.066	0.68
R-11 Interior w/TB	0.070	0.60
R-19 Interior	0.043	0.69
R-19 Interior w/TB	0.045	0.61
R-10 Exterior	0.070	0.60
R-12 Exterior	0.061	0.60
3.5 Foot Depth Below	w Grade	
Uninsulated	0.278	0.53
R-11 Interior	0.062	0.63
R-11 Interior w/TB	0.064	0.57
R-19 Interior	0.041	0.64
R-19 Interior w/TB	0.042	0.57
R-10 Exterior	0.064	0.57
R-12 Exterior	0.057	0.57
7 Foot Depth Below	Grade	
Uninsulated	0.193	0.46
R-11 Interior	0.054	0.56
R-11 Interior w/TB	0.056	0.42
R-19 Interior	0.037	0.57
R-19 Interior w/TB	0.038	0.43

	Below Grade Wall U-factor	Below Grade Slab F-factor
R-10 Exterior	0.056	0.42
R-12 Exterior	0.050	0.42

TB = Thermal Break

WAC 51-11C-61042 Section A104.2--Component description.

A104.2 Component description. All below-grade walls are assumed to be 8 inch concrete. The wall is assumed to extend from the slab upward to the top of the mud sill for the distance specified in Table A104.1, with 6 inches of concrete wall extending above grade.

Interior insulation is assumed to be fiberglass batts placed in the cavity formed by 2 x 4 framing on 24 inch centers with 1/2 inch gypsum board as the interior finish material. Exterior insulation is assumed to be applied directly to the exterior of the below-grade wall from the top of the wall to the footing. The exterior case does not assume any interior framing or sheetrock.

In all cases, the entire wall surface is assumed to be insulated to the indicated nominal level with the appropriate framing and insulation application. Coefficients are listed for wall depths of 2, 3-1/2 and 7 feet below grade. Basements shallower than two feet should use on-grade slab coefficients.

Heat-loss calculations for wall areas above-grade should use above-grade wall U-factors, beginning at the mudsill.

NEW SECTION

WAC 51-11C-61043 Section A104.3--Insulation description.

- **A104.3 Insulation description.** Coefficients are listed for the following four configurations:
 - 1. Uninsulated: No insulation or interior finish.
- 2. **Interior insulation:** Interior 2 x 4 insulated wall without a thermal break between concrete wall and slab.
- 3. Interior insulation with thermal break: Interior 2 x 4 insulated wall with R-5 rigid board providing a thermal break between the concrete wall and the slab.
- 4. Exterior insulation: Insulation applied directly to the exterior surface of the concrete wall.

WAC 51-11C-61050 Section A105--Floors over unconditioned space.

NEW SECTION

WAC 51-11C-61051 Section A105.1--General.

A105.1 General. Tables A105.1(1), A105.1(2) and A105.1(3) list heat loss coefficients for floors over unconditioned spaces in units of Btu/h \bullet ft² \bullet °F.

They are derived from procedures listed in the ASHRAE Fundamentals Handbook, assuming an average outdoor temperature of $45\,^\circ\text{F}$, an average indoor temperature of $65\,^\circ\text{F}$ and a crawlspace area of $1350\,$ ft² and $100\,$ feet of perimeter. The crawlspace is assumed to be $2.5\,$ feet high, with $24\,$ inches below grade and $6\,$ inches above grade.

Table A105.1(1)
Default U-factors for Floors
over Vented Crawlspace or
Unheated Basement

Nomina	l R-value	U-factor	
Floor	Perimeter	Post & Beam	Joists
0	0	0.112	0.134
	11	0.100	0.116
	19	0.098	0.114
	30	0.093	0.107
11	0	0.052	0.056
	11	0.048	0.052
19	0	0.038	0.041
	11	0.036	0.038
22	0	0.034	0.037
	11	0.033	0.035
25	0	0.032	0.034
	11	0.031	0.033
30	0	0.028	0.029
	11	0.027	0.028
38	0	0.024	0.025
	11	0.024	0.024

Table A105.1(2)
Default U-factors for Floors over Heated Plenum Crawlspaces

Nominal R-value Perimeter	U-factor
11	0.085
19	0.075
30	0.069

Note:

Crawlspaces used as heated plenums have approximately 30 percent higher heat loss rate than unvented crawlspaces with the same assumed ACH. Default U-factors in Table A105.1(2) reflect this higher rate of heat loss.

Table A105.1(3)
Default U-factors for Exposed Floors

Nominal	U-factor				
R-value	Concrete	Wood Joist	Metal Joist		
R-11	0.077	0.088	0.14		
R-15	0.059	0.076	0.12		
R-19	0.048	0.062	0.11		
R-21	0.043	0.057	0.11		
R-25	0.037	0.051	0.10		
R-30	0.031	0.040	0.09		
R-38	0.025	0.034	0.08		

NEW SECTION

WAC 51-11C-61052 Section A105.2--Crawlspace description.

A105.2 Crawlspace description. Four configurations are considered: Naturally ventilated crawlspace, mechanically vented crawlspace, heated plenum crawlspace and exposed floor.

- **A105.2.1 Naturally ventilated crawlspaces.** Assumed to have 3.0 air changes per hour, with at least 1.0 ft 2 of net-free ventilation in the foundation for every 300 ft 2 of crawlspace floor area. The crawlspace is not actively heated. Floors over unheated areas, such as garages, may only use those values which have R-0 perimeter insulation.
- **A105.2.2 Mechanically ventilated crawlspaces.** Assume to have 1.5 air changes per hour, with less than 1.0 ft 2 of net-free ventilation in the foundation for every 300 ft 2 of crawlspace floor area. The crawlspace is not actively heated. Floors over unheated basements may only use those values which have R-O perimeter insulation.
- A105.2.3 Heated plenum crawlspaces. Assumed to have 0.25 air changes per hour, with no foundation vents. Heated supply air from central furnace is blown into a crawlspace and allowed to enter the

living space unducted via holes cut into the floor.

A105.2.4 Exposed floors. Assumes no buffer space, and a covering of 1/2 inch T1-11 on the exterior of the cavity exposed to the outside air or rigid insulation below a concrete floor, such as over parking garages.

NEW SECTION

WAC 51-11C-61053 Section A105.3--Construction description.

A105.3 Construction description. Floors are assumed to be either joisted floors framed on 16 inch centers, or post and beam on 4 foot by 8 foot squares. Insulation is assumed to be installed under the subflooring between the joists or beams with no space between the insulation and the subfloor. Insulation is assumed to be uncompressed. Exposed floors also include concrete with continuous rigid insulation assumed.

Perimeter insulation is assumed to extend from the top of the rim joist to the crawlspace floor and then inward along the ground (on top of the ground cover) for at least 24 inches.

Floor coverings are assumed to be light carpet with rubber pad.

NEW SECTION

WAC 51-11C-61060 Section A106--On-grade slab floors.

NEW SECTION

WAC 51-11C-61061 Section A106.1--General.

A106.1 General. Table A106.1 lists heat loss coefficients for heated on-grade slab floors, in units of Btu/h \bullet °F per lineal foot of perimeter.

Table A106.1 Default F-factors for On-Grade Slabs

Insulation Type	R-0	R-5	R-10	R-15	R-20	R-30
Unheated Slab						

Insulation Type	R-0	R-5	R-10	R-15	R-20	R-30
Uninsulated slab	0.73					
2 ft. Horizontal (No thermal break)		0.70	0.70	0.69		
4 ft. Horizontal (No thermal break)		0.67	0.64	0.63		
2 ft. Vertical		0.58	0.54	0.52		
4 ft. Vertical		0.54	0.48	0.45		
Fully insulated slab*			0.36	0.31	0.26	0.21
			Heate	d Slab		
Uninsulated slab	0.84					
Fully insulated slab*		0.74	0.55	0.44	0.39	0.32
R-5 Center (With perimeter insulation)			0.66	0.62		
R-10 Center (With perimeter insulation)				0.51		
3 ft. Vertical			0.78			

^{*}Edge insulation R-10 regardless of the below slab insulation level.

WAC 51-11C-61062 Section A106.2--Component description.

A106.2 Component description. All on-grade slab floors are assumed to be 6 inch concrete poured directly onto the earth. The bottom of the slab is assumed to be at grade line. Monolithic and floating slabs are not differentiated.

Soil is assumed to have a conductivity of 0.75 Btu/h \bullet ft² \bullet °F. Slabs 2 feet or more below grade should use basement coefficients.

NEW SECTION

WAC 51-11C-61063 Section A106.3--Insulation description.

- **A106.3 Insulation description.** Coefficients are provided for the following three configurations:
- 1. Two foot (or four foot) vertical: Insulation is applied directly to the slab exterior, extending downward from the top of the slab to a depth of 2 feet (or 4 feet) below grade.
- 2. Two foot (or four foot) horizontal: Insulation is applied directly to the underside of the slab, and run horizontally from the perimeter inward for 2 feet (or 4 feet). The slab edge is exposed in this configuration.

Note: A horizontal installation with a thermal break of at least R-5 at the slab edge should use the vertical-case F-factors.

3. Fully insulated slab: Insulation extends from the top of the slab, along the entire perimeter, and completely covers the area under the slab. Thicker perimeter insulation covers the slab edge and extends 2 feet under the slab.

NEW SECTION

WAC 51-11C-61070 Section A107--Default U-factors for doors.

NEW SECTION

WAC 51-11C-61071 Section A107.1--Doors without NFRC certification.

A107.1 Doors without NFRC certification. Doors that do not have NFRC certification shall be assigned the appropriate U-factor from Tables A107.1(1) through A107.1(4).

NEW SECTION

WAC 51-11C-610711 Table A107.1(1)--Default U-factors for doors.

Table A107.1(1)
Default U-factors for Doors

Door Type Swing	No Glazed Fenestration ing Doors (Rough op	Single Glazing bening - 38 in	Double Glazing with 1/4 in. Airspace . x 82 in.)	Double Glazing with 1/2 in. Airspace	Double Glazing with e = 0.10, 1/2 in. Argon
Slab Doors					
Wood slab in wood frame ^a	0.46				
6% glazed fenestration (22 in. x 8 in. lite)	-	0.48	0.47	0.46	0.44
25% glazed fenestration (22 in. x 36 in. lite)	-	0.58	0.48	0.46	0.42

D. T	No Glazed	Single	Double Glazing with 1/4 in.	Double Glazing with 1/2 in.	Double Glazing with e = 0.10, 1/2 in.
Door Type	Fenestration	Glazing	Airspace	Airspace	Argon
45% glazed fenestration (22 in. x 64 in. lite)	-	0.69	0.49	0.46	0.39
More than 50% glazed fenestration		Use Table C appropriate	C303.1.3(1)/R303	3.1.3(1) as	
Insulated steel slab with wood edge in wood frame ^a	0.16				
6% glazed fenestration (22 in. x 8 in. lite)	-	0.21	0.20	0.19	0.18
25% glazed fenestration (22 in. x 36 in. lite)	-	0.39	0.28	0.26	0.23
45% glazed fenestration (22 in. x 64 in. lite)	-	0.58	0.38	0.35	0.26
More than 50% glazed fenestration		Use Table Cappropriate	C303.1.3(1)/R303	3.1.3(1) as	
Foam insulated steel slab with metal edge in steel frame ^b	0.37				
6% glazed fenestration (22 in. x 8 in. lite)	-	0.44	0.42	0.41	0.39
25% glazed fenestration (22 in. x 36 in. lite)	-	0.55	0.50	0.48	0.44
45% glazed fenestration (22 in. x 64 in. lite)	-	0.71	0.59	0.56	0.48
More than 50% glazed fenestration		Use Table Cappropriate	C303.1.3(1)/R303	3.1.3(1) as	
Cardboard honeycomb slab with metal edge in steel frame ^b	0.61				
Style and Rail Doors					
Sliding glass doors/French doors	Use Table C303.1.3(1)/R303.1.3(1) as appropriate				
Site-Assembled Style and Rail Door	s				
Aluminum in aluminum frame	_	1.32	0.99	0.93	0.79
Aluminum in aluminum frame with thermal break	-	1.13	0.80	0.74	0.63

 $^{^{}a}$ Thermally broken sill (add 0.03 for nonthermally broken sill) b Nonthermally broken sill c Nominal U-factors are through the center of the insulated panel before consideration of thermal bridges around the edges of the door sections and due to the frame.

WAC 51-11C-610712 Table A107.1(2)--Default U-factors for revolving doors.

Table A107.1(2)
Default U-factors for Revolving Doors

Revolving Doors				
Size (W x H)	U-Factor			
3-wing				
8 ft. x 7 ft.	0.79			
10 ft. x 8 ft.	0.80			
4-wing				
7 ft. x 6.5 ft.	0.63			
7 ft. x 7.5 ft.	0.64			
Open				
82 in. x 84 in.	1.32			

NEW SECTION

WAC 51-11C-610713 Table A107.1(3)--Default U-factors for steel emergency doors.

Table A107.1(3)
Default U-factors for Steel Emergency Doors

Double-skin Steel Emergency Exit Doors				
Core Insulation	3 ft. x 6 ft. 8 in.	6 ft. x 6 ft. 8 in.		
1-3/8 in. thickness				
Honeycomb kraft paper	0.57	0.52		
Mineral wool, steel ribs	0.44	0.36		
Polyurethane foam	0.34	0.28		
1-3/4 in. thickness				
Honeycomb kraft paper	0.57	0.54		
Mineral wool, steel ribs	0.41	0.33		
Polyurethane foam	0.31	0.26		
1-3/8 in. thickness				
Honeycomb kraft paper	0.60	0.55		
Mineral wool, steel ribs	0.47	0.39		
Polyurethane foam	0.37	0.31		
1-3/4 in. thickness				
Honeycomb kraft paper	0.60	0.57		
Mineral wool, steel ribs	0.44	0.37		
Polyurethane foam	0.34	0.30		

WAC 51-11C-610714 Table A107.1(4) -- Default U-factors for steel garage and hangar doors.

Table A107.1(4) Default U-factors for Steel Garage and Hangar Doors

Double-skin Steel Garage and Aircraft Hangar Doors						
	One-pied	e tilt-up ^a	Sectional tilt-up ^b	Aircraft hangar		
Insulation ^e	8 ft. x 7 ft.	16 ft. x 7 ft.	9 ft. x 7 ft.	72 ft. x 12 ft. ^c	240 ft. x 50 ft.d	
1-3/8 in. thickness EPS, steel ribs XPS, steel ribs	0.36 0.33	0.33 0.31	0.34 - 0.39 0.31 - 0.36			
2 in. thickness EPS, steel ribs XPS, steel ribs	0.31 0.29	0.28 0.26	0.29 - 0.33 0.27 - 0.31			
3 in. thickness EPS, steel ribs XPS, steel ribs	0.26 0.24	0.23 0.21	0.25 - 0.28 0.24 - 0.27			
4 in. thickness EPS, steel ribs XPS, steel ribs	0.23 0.21	0.20 0.19	0.23 - 0.25 0.21 - 0.24			
6 in. thickness EPS, steel ribs XPS, steel ribs	0.20 0.19	0.16 0.15	0.20 - 0.21 0.19 - 0.21			
4 in. thickness Noninsulated Expanded polystyrene Mineral wool, steel ribs Extruded polystyrene				1.10 0.25 0.25 0.23	1.23 0.16 0.16 0.15	
6 in. thickness Noninsulated Expanded polystyrene Mineral wool, steel ribs Extruded polystyrene				1.10 0.21 0.23 0.20	1.23 0.13 0.13 0.12	
Uninsulated All products	1.15					

^aValues are for thermally broken or thermally unbroken doors.

NEW SECTION

WAC 51-11C-61080 Section A108--Air infiltration.

^bLower values are for thermally broken doors; upper values are for doors with no thermal break.

^cTypical size for a small private airplane (single-engine or twin).

^dTypical hangar door for a midsize commercial jet airliner. ^eEPS is extruded polystyrene, XPS is expanded polystyrene.

WAC 51-11C-61081 Section A108.1--General.

A108.1 General. Tables A108.1(1) and A108.1(2) list effective air change rates and heat capacities for heat loss due to infiltration for Single-Family Residential.

The estimated seasonal average infiltration rate in air changes per hour (ACH) is given for standard air-leakage control (see Section R402.4 for air leakage requirements for Single-Family Residential). The effective air change rate shall be used in calculations for compliance under either the Component Performance or Systems Analysis approaches.

Heat loss due to infiltration shall be computed using the following equation:

 $Q_{infil} = ACH_{eff} * HCP$

Where:

 Q_{infil} = Heat loss due to air infiltration.

 ACH_{eff} = The effective air infiltration rate in

Table A108.1(1)

HCP = The Heat Capacity Density Product for

the appropriate elevation or climate

zone as given below.

Table A108.1(1) Assumed Effective Air Changes per Hour

Air-Leakage	Air Changes per Hour		
Control Package	Natural Effectiv		
Standard	0.35	0.35	

Table A108.1(2) Default Heat Capacity/Density Product for Air

Zone Average Elevation		Heat Capacity/Density
1	Mean Sea Level	0.0180 Btu/h ● °F
2	2000	0.0168 Btu/h ● °F
3	3000	0.0162 Btu/h ● °F

NEW SECTION

WAC 51-11C-70000 Appendix B--Default internal load values and schedules.

WAC 51-11C-71010 Section B101--General.

B101.1 Scope. The following default internal load values and schedules shall apply to Section C407.

NEW SECTION

WAC 51-11C-71020 Section B102--Default tables of internal loads.

B102 Default tables of internal loads. Default occupancy densities, receptacle power densities and service hot water consumption are included in Table B102.

NEW SECTION

WAC 51-11C-71021 Table B102--Acceptable occupancy densities, receptacle power densities and service hot water consumption.

TABLE B102
Acceptable Occupancy Densities, Receptacle Power Densities and Service Hot Water Consumption^a

Building Type	Occupancy Density ^b ft²/Person (Btu/h • ft²)	Receptacle Power Density ^c , Watts/ft ² (Btu/h ● ft ²)	Service Hot Water Quantities ^d Btu/h per person
Assembly	50 (4.60)	0.25 (0.85)	215
Health/Institutional	200 (1.15)	1.00 (3.41)	135
Hotel/Motel	250 (0.92)	0.25 (0.85)	1,110
Light Manufacturing	750 (0.31)	0.20 (0.68)	225
Office	275 (0.84)	0.75 (2.56)	175
Parking Garage	NA	NA	NA
Restaurant	100 (2.30)	0.10 (0.34)	390
Retail	300 (3.07)	0.25 (0.85)	135
School	75 (3.07)	0.50 (1.71)	215
Warehouse	15,000 (0.02)	0.10 (0.34)	225

^aThe occupancy densities, receptacle power densities, and service hot water consumption values are from ASHRAE Standard 90.1-1989 and addenda.

^bValues are in square feet of conditioned floor area per person. Heat generation in Btu per person per hour is 230 sensible and 190 latent. Figures in parenthesis are equivalent Btu per hour per square foot.

^cValues are in watts per square foot of conditioned floor area. Figures in parenthesis are equivalent Btu per hour per square foot. These values are the minimum acceptable. If other process loads are not input (such as for computers, cooking, refrigeration, etc.), it is recommended that receptacle power densities be increased until total process energy consumption is equivalent to 25 percent of the total.

WAC 51-11C-71030 Section B103--Default schedules.

B103 Default schedules. Default schedules for occupancy, lighting, receptacles, HVAC, service hot water, and elevators are included in Tables B103(1) through B103(10).

WAC 51-11C-71031 Table B103(1)--Assembly occupancy.

Table B103(1)
Assembly Occupancy^a

	Schedule			R	le for Lig Receptacl	e				Н	ile for S ot Wate	er		chedul Elevat	or
Hour of Day (time)		<i>Percent of</i> cimum L			<i>Percent o</i> ximum L	,		ule for l System			<i>ercent d</i> imum I			P <i>ercen</i> ximum	t of Load
` ′	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
2 (1-2am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
3 (2-3am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
4 (3-4am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
5 (4-5am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0
6 (5-6am)	0	0	0	5	5	5	On	Off	Off	0	0	0	0	0	0
7 (6-7am)	0	0	0	35/40	5	5	On	On	On	0	0	0	0	0	0
8 (7-8am)	0	0	0	35/40	30	30	On	On	On	0	0	0	0	0	0
9 (8-9am)	20	20	10	35/40	30	30	On	On	On	0	0	0	0	0	0
10 (9-10am)	20	20	10	65/75	40/50	30	On	On	On	5	5	5	0	0	0
11 (10-11am)	20	20	10	65/75	40/50	30	On	On	On	5	5	5	0	0	0
12 (11-12pm)	80	60	10	65/75	40/50	30	On	On	On	35	20	10	0	0	0
13 (12-1pm)	80	60	10	65/75	40/50	55/65	On	On	On	5	0	0	0	0	0
14 (1-2pm)	80	60	70	65/75	40/50	55/65	On	On	On	5	0	0	0	0	0
15 (2-3pm)	80	60	70	65/75	40/50	55/65	On	On	On	5	0	0	0	0	0
16 (3-4pm)	80	60	70	65/75	40/50	55/65	On	On	On	5	0	0	0	0	0
17 (4-5pm)	80	60	70	65/75	40/50	55/65	On	On	On	5	0	0	0	0	0
18 (5-6pm)	80	60	70	65/75	40/50	55/65	On	On	On	0	0	0	0	0	0
19 (6-7pm)	20	60	70	65/75	40/50	55/65	On	On	On	0	0	0	0	0	0
20 (7-8pm)	20	60	70	65/75	40/50	55/65	On	On	On	0	65	65	0	0	0
21 (8-9pm)	20	60	70	65/75	40/50	55/65	On	On	On	0	30	30	0	0	0
22 (9-10pm)	20	80	70	65/75	40/50	55/65	On	On	On	0	0	0	0	0	0
23 (10-11pm)	10	10	20	25	40/50	5	On	On	On	0	0	0	0	0	0
24 (11-12am)	0	0	0	5	5	5	Off	Off	Off	0	0	0	0	0	0

	Schedul			F	Receptac					Н	ot Wat			hedul Elevat	tor
Hour of Day (time)		<i>Percent of</i> cimum L			Percent o ximum I	,		ule for System	HVAC		<i>ercent o</i> imum l			P <i>ercen</i> ximum	t of Load
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
Fotal/Day	710	750	700	1010/ 1155	660/ 800	745/845	1800	1700	1700	70	125	115	0	0	0
Total/Week		50.50	hours		64.55/ 74.20	hours		124	hours		5.9	hours		0	hours
Total/Year		2633	hours		3357/ 3869	hours		6465	hours		308	hours		0	hours

WAC 51-11C-71032 Table B103(2)--Health occupancy.

Table B103(2)

Health Occupancy^a

		nedule f ecupanc		Schedule Re	for Ligl ceptacle						lle for S ot Wate		Schedu	ıle for l	Elevator
Hour of Day (time)		ercent o imum L	,		rcent of mum Lo		Schedu	lle for I System			ercent o imum L	,		Percent ximum	
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
2 (1-2am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
3 (2-3am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
4 (3-4am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
5 (4-5am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
6 (5-6am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
7 (6-7am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
8 (7-8am)	10	10	0	45/50	20	5	On	On	On	17	1	1	2	2	0
9 (8-9am)	50	30	5	80/90	35/40	10	On	On	On	58	20	1	75	46	2
10 (9-10am)	80	40	5	80/90	35/40	10	On	On	On	66	28	1	100	70	2
11 (10-11am)	80	40	5	80/90	35/40	10	On	On	On	78	30	1	100	70	2
12 (11-12pm)	80	40	5	80/90	35/40	10	On	On	On	82	30	1	100	70	2
13 (12-1pm)	80	40	5	80/90	35/40	10	On	On	On	71	24	1	75	51	2
14 (1-2pm)	80	40	5	80/90	35/40	10	On	On	On	82	24	1	100	51	2
15 (2-3pm)	80	40	5	80/90	35/40	10	On	On	On	78	23	1	100	51	2
16 (3-4pm)	80	40	5	80/90	35/40	10	On	On	On	74	23	1	100	51	2
17 (4-5pm)	80	40	0	30	35/40	5	On	On	On	63	23	1	100	51	0
18 (5-6pm)	50	10	0	30	35/40	5	On	On	On	41	10	1	100	25	0
19 (6-7pm)	30	10	0	30	10	5	On	On	On	18	1	1	52	2	0
20 (7-8pm)	30	0	0	30	10	5	On	On	On	18	1	1	52	0	0
21 (8-9pm)	20	0	0	30	10	5	On	On	On	18	1	1	52	0	0
22 (9-10pm)	20	0	0	30	10	5	On	On	On	10	1	1	28	0	0

^aSchedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. These values may be used only if actual schedules are not known.

^bLighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Hour of Day (time)	O _C	hedule for ccupance ccent of imum L	y f	Pe	e for Lig eceptacle ercent of mum Lo		Schedu	le for I System		H P	ile for S ot Wate ercent of imum L	r f	1	ıle for E Percent o ximum 1	of
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
23 (10-11pm)	0	0	0	30	10	5	On	On	On	1	1	1	0	0	0
24 (11-12am)	0	0	0	10	10	5	On	On	On	1	1	1	0	0	0
Fotal/Day	850	380	40	975/ 1060	500/ 550	160	2400	2400	2400	783	249	24	1136	540	16
Total/Week		46.70	hours			hours		168	hours		41.88	hours		62.36	hours
Total/Year		2435	hours		60.10 2878/ 3134	hours		8760	hours		2148	hours		3251	hours

WAC 51-11C-71033 Table B103(3)--Hotel/motel occupancy. Table B103(3) Hotel/Motel Occupancy^a

		edule fo		Schedule Re	for Lig ceptacle						ile for S ot Wate		Schedu	ıle for I	Elevator
Hour of Day (time)		rcent oj mum L			rcent of mum Lo		Schedu	ile for I System			ercent oj imum L			Percent ximum	
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	90	90	70	20	20	30	On	On	On	20	20	25	40	44	55
2 (1-2am)	90	90	70	15	20	30	On	On	On	15	15	20	33	35	55
3 (2-3am)	90	90	70	10	10	20	On	On	On	15	15	20	33	35	43
4 (3-4am)	90	90	70	10	10	20	On	On	On	15	15	20	33	35	43
5 (4-5am)	90	90	70	10	10	20	On	On	On	20	20	20	33	35	43
6 (5-6am)	90	90	70	20	10	20	On	On	On	25	25	30	33	35	43
7 (6-7am)	70	70	70	40	30	30	On	On	On	50	40	50	42	40	52
8 (7-8am)	40	50	70	50	30	40	On	On	On	60	50	50	42	32	52
9 (8-9am)	40	50	50	40	40	40	On	On	On	55	50	50	52	45	65
10 (9-10am)	20	30	50	40	40	30	On	On	On	45	50	55	52	45	65
11 (10-11am)	20	30	50	25	30	30	On	On	On	40	45	50	40	42	53
12 (11-12pm)	20	30	30	25	25	30	On	On	On	45	50	50	51	60	60
13 (12-1pm)	20	30	30	25	25	30	On	On	On	40	50	40	51	65	53
14 (1-2pm)	20	30	20	25	25	20	On	On	On	35	45	40	51	65	51
15 (2-3pm)	20	30	20	25	25	20	On	On	On	30	40	30	51	65	50
16 (3-4pm)	30	30	20	25	25	20	On	On	On	30	40	30	51	65	44
17 (4-5pm)	50	30	30	25	25	20	On	On	On	30	35	30	63	65	64
18 (5-6pm)	50	50	40	25	25	20	On	On	On	40	40	40	80	75	62

^aSchedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. These values may be used only if actual schedules are not known.

^bLighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

	Oce	edule fo	y		ceptacle					Н	ale for S ot Wate	r			Elevator
Hour of Day (time)		<i>rcent of</i> mum Lo			<i>rcent of</i> mum Lo	ad	Schedu	lle for I System			<i>ercent o</i> imum L	,		Percent ximum	
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
19 (6-7pm)	50	60	40	60	60	50	On	On	On	55	55	50	86	80	65
20 (7-8pm)	70	60	60	80	70	70	On	On	On	60	55	50	70	80	63
21 (8-9pm)	70	60	60	90	70	80	On	On	On	50	50	40	70	75	63
22 (9-10pm)	80	70	80	80	70	60	On	On	On	55	55	50	70	75	63
23 (10-11pm)	90	70	80	60	60	50	On	On	On	45	40	40	45	55	40
24 (11-12am)	90	70	80	30	30	30	On	On	On	25	30	20	45	55	40
Гotal/Day	1390	1390	1300	855	785	810	2400	2400	2400	915	930	900	1217	1303	1287
Total/Week		96.40	hours		58.70	hours		168.0	hours		64.05	hours		86.75	hours
Total/Year		5026	hours		3061	hours		8760	hours		3340	hours		4523	hours

^aSchedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

NEW SECTION

WAC 51-11C-71034 Table B103(4)--Light manufacturing occupancy.

Table B103(4)
Light Manufacturing Occupancy^a

		edule f cupanc	-	Schedule Re-	for Lig ceptacle	_					le for S ot Wate		Schedu	ıle for I	Elevator
Hour of Day (time)		rcent o mum L			rcent of mum Lo		Schedu	lle for I System			ercent oj imum L			Percent ximum	9
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
2 (1-2am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
3 (2-3am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
4 (3-4am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
5 (4-5am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
6 (5-6am)	0	0	0	10	5	5	Off	Off	Off	8	8	7	0	0	0
7 (6-7am)	10	10	5	10	10	5	On	On	Off	7	7	4	0	0	0
8 (7-8am)	20	10	5	30	10	5	On	On	Off	19	11	4	35	16	0
9 (8-9am)	95	30	5	85/90	30	5	On	On	Off	35	15	4	69	14	0
10 (9-10am)	95	30	5	85/90	30	5	On	On	Off	38	21	4	43	21	0
11 (10-11am)	95	30	5	85/90	30	5	On	On	Off	39	19	4	37	18	0
12 (11-12pm)	95	30	5	85/90	30	5	On	On	Off	47	23	6	43	25	0
13 (12-1pm)	50	10	5	75/80	15	5	On	On	Off	57	20	6	58	21	0
14 (1-2pm)	95	10	5	85/90	15	5	On	On	Off	54	19	9	48	13	0
15 (2-3pm)	95	10	5	85/90	15	5	On	On	Off	34	15	6	37	8	0
16 (3-4pm)	95	10	5	85/90	15	5	On	On	Off	33	12	4	37	4	0
17 (4-5pm)	95	10	5	85/90	15	5	On	On	Off	44	14	4	46	5	0

	Oc	edule f	y	Re	e for Ligh eceptacle					Н	ile for S ot Wate	r			Elevator
Hour of Day (time)		rcent o mum L			<i>ercent of</i> imum Lo		Schedu	ile for 1 System			ercent o imum L			Percent (ximum)	
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
18 (5-6pm)	30	5	5	50	5	5	On	On	Off	26	7	4	62	6	0
19 (6-7pm)	10	5	0	30	5	5	On	Off	Off	21	7	4	20	0	0
20 (7-8pm)	10	0	0	30	5	5	On	Off	Off	15	7	4	12	0	0
21 (8-9pm)	10	0	0	20	5	5	On	Off	Off	17	7	4	4	0	0
22 (9-10pm)	10	0	0	20	5	5	On	Off	Off	8	9	7	4	0	0
23 (10-11pm)	5	0	0	10	5	5	Off	Off	Off	5	5	4	0	0	0
24 (11-12am)	5	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
Fotal/Day	920	200	60	995/ 1040	280	120	1600	1200	0	537	256	113	555	151	0
Total/Week		48.60	hours		53.75/5 6.00	hours		92.00	hours		30.54	hours		29.26	hours
Total/Year		2534	hours		2795/ 2920	hours		4797	hours		1592	hours		1526	hours

WAC 51-11C-71035 Table B103(5) -- Office occupancy. Table B103(5) Office Occupancy

		edule fo		Schedule Rec	for Ligl eptacle						lle for So ot Wate		Schedu	ıle for I	Elevator
Hour of Day (time)		rcent of mum L			<i>cent of</i> num Lo		Schedu	ile for I System			<i>ercent oj</i> imum L			Percent (ximum)	
(time)	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
2 (1-2am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
3 (2-3am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
4 (3-4am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
5 (4-5am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
6 (5-6am)	0	0	0	10	5	5	Off	Off	Off	8	8	7	0	0	0
7 (6-7am)	10	10	5	10	10	5	On	On	Off	7	7	4	0	0	0
8 (7-8am)	20	10	5	30	10	5	On	On	Off	19	11	4	35	16	0
9 (8-9am)	95	30	5	65/90	30	5	On	On	Off	35	15	4	69	14	0
10 (9-10am)	95	30	5	65/90	30	5	On	On	Off	38	21	4	43	21	0
11 (10-11am)	95	30	5	65/90	30	5	On	On	Off	39	19	4	37	18	0
12 (11-12pm)	95	30	5	65/90	30	5	On	On	Off	47	23	6	43	25	0
13 (12-1pm)	50	10	5	55/80	15	5	On	On	Off	57	20	6	58	21	0
14 (1-2pm)	95	10	5	65/90	15	5	On	On	Off	54	19	9	48	13	0

^aSchedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**^bLighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Hour of Day (time)	Oc Pe	edule for cupance creent of mum L	y f	Pe	for Ligh ceptacle rcent of mum Lo		Schedu	lle for I System		H P	ule for S ot Wate ercent o imum L	r f		ule for I Percent (9
(time)	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
15 (2-3pm)	95	10	5	65/90	15	5	On	On	Off	34	15	6	37	8	0
16 (3-4pm)	95	10	5	65/90	15	5	On	On	Off	33	12	4	37	4	0
17 (4-5pm)	95	10	5	65/90	15	5	On	On	Off	44	14	4	46	5	0
18 (5-6pm)	30	5	5	35/50	5	5	On	On	Off	26	7	4	62	6	0
19 (6-7pm)	10	5	0	30	5	5	On	On	Off	21	7	4	20	0	0
20 (7-8pm)	10	0	0	30	5	5	On	Off	Off	15	7	4	12	0	0
21 (8-9pm)	10	0	0	20	5	5	On	Off	Off	17	7	4	4	0	0
22 (9-10pm)	10	0	0	20	5	5	On	Off	Off	8	9	7	4	0	0
23 (10-11pm)	5	0	0	10	5	5	Off	Off	Off	5	5	4	0	0	0
24 (11-12am)	5	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
Total/Day	920	200	60	800/ 1040	280	120	1600	1200	0	537	256	113	555	151	0
Total/Week		48.60	hours		44.00/ 56.00	hours		92.00	hours		30.54	hours		29.26	hours
Total/Year		2534	hours		2288/ 2920	hours		4797	hours		1592	hours		1526	hours

Table B103(6) -- Parking garage occupancy. WAC 51-11C-71036 Table B103(6) Parking Garage Occupancy

ш	our of Day	Oce	edule focupancy	y	R	le for Lig Receptacle Percent of	•	Sah	edule 1	for		le for S ot Wate ercent o	er		Chedule Elevate Percent	or
11	(time)		mum L			ximum Lo			AC Sys	-		mum I			<i>r erceni</i> aximum	
		Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1	(12-1am)				50/100	50/100	50/100									
2	(1-2am)				50/100	50/100	50/100									
3	(2-3am)				50/100	50/100	50/100									
4	(3-4am)				50/100	50/100	50/100									
5	(4-5am)				50/100	50/100	50/100									
6	(5-6am)				50/100	50/100	50/100									
7	(6-7am)				100	100	50/100									
8	(7-8am)				100	100	50/100									
9	(8-9am)				100	100	50/100									
10	(9-10am)				100	100	50/100		Based						Include	ed
11	(10-11am)				100	100	50/100		on						with	

^aSchedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**^bLighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

			edule fo			le for Lig Receptacle						ule for S lot Wate		S	chedule Elevat	-
Hour of Da (time)	ıy		rcent of mum L			Percent of ximum Lo			nedule i	-		Percent o cimum I			Percent aximum	
		Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
12 (11-12pn	n)		N/A		100	100	50/100		likely			N/A			othe	r
13 (12-1pm))				100	100	50/100		use					(occupan	cies
14 (1-2pm)					100	100	50/100									
15 (2-3pm)					100	100	50/100									
16 (3-4pm)					100	100	50/100									
17 (4-5pm)					100	100	50/100									
18 (5-6pm)					100	50/100	50/100									
19 (6-7pm)					100	50/100	50/100									
20 (7-8pm)					100	50/100	50/100									
21 (8-9pm)					100	50/100	50/100									
22 (9-10pm))				100	50/100	50/100									
23 (10-11pn	n)				50/100	50/100	50/100									
24 (11-12an	n)				50/100	50/100	50/100									
Total/Day					2000/	1750/	1200/									
					2400	2400	2400									
Total/Week						129.50/ 168	hours									
Total/Year						6734/ 8760	hours									

^aSchedules for occupancy, lighting, receptacle, HVAC system and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. These values may be used only if actual schedules are not known.

^bLighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2. For parking garage lighting, the schedule has been revised to accompany the office schedule: The lighting in the parking garage is set to be on at 100 percent for all hours when the building occupancy is 10 percent or greater, but reduced to 50 percent (per Section C405.2) for all hours when the building occupancy is less than 10 percent. For a parking garage serving a use other than office, it is acceptable to modify the parking garage schedule to parallel that use.

NEW SECTION

WAC 51-11C-71037 Table B103(7)--Restaurant occupancy. Table B103(7) Restaurant Occupancy^a

		edule f cupanc	-	Schedule Re	for Ligl ceptacle	_				~	dule for Hot Wa	r Service ater	S	chedul Eleva	-
Hour of Day	Pe	rcent o	f	Pe	ercent of		S	chedule	for		Percen	t of		Percen	t of
(time)	Maxi	mum I	oad	Maxi	mum Lo	ad	HV	VAC Sys	stem	Ma	aximun	ı Load	Ma	ximun	1 Load
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	15	30	20	15	20	20	On	On	On	20	20	25	0	0	0
2 (1-2am)	15	25	20	15	15	15	On	On	On	15	15	20	0	0	0
3 (2-3am)	5	5	5	15	15	15	On	On	On	15	15	20	0	0	0
4 (3-4am)	0	0	0	15	15	15	Off	Off	Off	0	0	0	0	0	0

	~	edule f	~-	Schedule Re	e for Ligh eceptacle					~	dule for Hot Wa	: Service ater	S	chedul Eleva	
Hour of Day		rcent o	,		ercent of		~	chedule			Percen			Percen	
(time)		mum L	⊿oad		mum Lo	ad		VAC Sy	stem		aximum	Load		ximun	n Load
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
5 (4-5am)	0	0	0	15	15	15	Off	Off	Off	0	0	0	0	0	0
6 (5-6am)	0	0	0	20	15	15	Off	Off	Off	0	0	0	0	0	0
7 (6-7am)	0	0	0	35/40	30	30	Off	Off	Off	0	0	0	0	0	0
8 (7-8am)	5	0	0	35/40	30	30	On	Off	Off	60	0	0	0	0	0
9 (8-9am)	5	0	0	55/60	55/60	45/50	On	Off	Off	55	0	0	0	0	0
10 (9-10am)	5	5	0	55/60	55/60	45/50	On	On	Off	45	50	0	0	0	0
11 (10-11am)	20	20	10	85/90	75/80	65/70	On	On	On	40	45	50	0	0	0
12 (11-12pm)	50	45	20	85/90	75/80	65/70	On	On	On	45	50	50	0	0	0
13 (12-1pm)	80	50	25	85/90	75/80	65/70	On	On	On	40	50	40	0	0	0
14 (1-2pm)	70	50	25	85/90	75/80	65/70	On	On	On	35	45	40	0	0	0
15 (2-3pm)	40	35	15	85/90	75/80	65/70	On	On	On	30	40	30	0	0	0
16 (3-4pm)	20	30	20	85/90	75/80	65/70	On	On	On	30	40	30	0	0	0
17 (4-5pm)	25	30	25	85/90	75/80	55/60	On	On	On	30	35	30	0	0	0
18 (5-6pm)	50	30	35	85/90	85/90	55/60	On	On	On	40	40	40	0	0	0
19 (6-7pm)	80	70	55	85/90	85/90	55/60	On	On	On	55	55	50	0	0	0
20 (7-8pm)	80	90	65	85/90	85/90	55/60	On	On	On	60	55	50	0	0	0
21 (8-9pm)	80	70	70	85/90	85/90	55/60	On	On	On	50	50	40	0	0	0
22 (9-10pm)	50	65	35	85/90	85/90	55/60	On	On	On	55	55	50	0	0	0
23 (10-11pm)	35	55	20	45/50	45/50	45/50	On	On	On	45	40	40	0	0	0
24 (11-12am)	20	35	20	30	30	30	On	On	On	25	30	20	0	0	0
Fotal/Day	750	740	485	1370/ 1455	1290/ 1365	1040/ 1115	2000	1800	1700	790	730	625	0	0	0
Total/Week		49.75	hours		91.80/ 97.55	hours		135	hours		53.05	hours		0	hours
Fotal/Year		2594	hours		4774/ 5086	hours		7039	hours		2766	hours		0	hours

^aSchedules for occupancy, lighting, receptacle, HVAC system and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**^bLighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

NEW SECTION

WAC 51-11C-71038 Table B103(8) -- Retail occupancy. Table B103(8) Retail Occupancy^a

Hour of Day (time)	Schedule for Occupancy Percent of Maximum Load		Schedule for Lighting ^b / Receptacle Percent of Maximum Load			Schedule for HVAC System			Maximum Load			Schedule for Elevator <i>Percent of</i> Maximum Load			
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1am)	0	0	0	5	5	5	Off	Off	Off	4	11	7	0	0	0
2 (1-2am)	0	0	0	5	5	5	Off	Off	Off	5	10	7	0	0	0
3 (2-3am)	0	0	0	5	5	5	Off	Off	Off	5	8	7	0	0	0
4 (3-4am)	0	0	0	5	5	5	Off	Off	Off	4	6	6	0	0	0
5 (4-5am)	0	0	0	5	5	5	Off	Off	Off	4	6	6	0	0	0
6 (5-6am)	0	0	0	5	5	5	Off	Off	Off	4	6	6	0	0	0

Schedule for Occupancy Percent of Hour of Day (time) Maximum Load		Schedule for Lighting ^b / Receptacle Percent of Maximum Load			Schedule for HVAC System Wt. Sot. Sup.			Maximum Load			Schedule for Elevator Percent of Maximum Load				
• ` ` ′	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
7 (6-7am)	0	0	0	5	5	5	On	On	Off	4	7	7	0	0	0
8 (7-8am)	10	10	0	20	10	5	On	On	Off	15	20	10	12	9	0
9 (8-9am)	20	20	0	50	30	10	On	On	On	23	24	12	22	21	0
10 (9-10am)	50	50	10	85/90	55/60	10	On	On	On	32	27	14	64	56	11
11 (10-11am)	50	60	20	85/90	85/90	40	On	On	On	41	42	29	74	66	13
12 (11-12pm)	70	80	20	85/90	85/90	40	On	On	On	57	54	31	68	68	35
13 (12-1pm)	70	80	40	85/90	85/90	55/60	On	On	On	62	59	36	68	68	37
14 (1-2pm)	70	80	40	85/90	85/90	55/60	On	On	On	61	60	36	71	69	37
15 (2-3pm)	70	80	40	85/90	85/90	55/60	On	On	On	50	49	34	72	70	39
16 (3-4pm)	80	80	40	85/90	85/90	55/60	On	On	On	45	48	35	72	69	41
17 (4-5pm)	70	80	40	85/90	85/90	55/60	On	On	On	46	47	37	73	66	38
18 (5-6pm)	50	60	20	85/90	85/90	40	On	On	Off	47	46	34	68	58	34
19 (6-7pm)	50	20	10	55/60	50	20	On	On	Off	42	44	25	68	47	3
20 (7-8pm)	30	20	0	55/60	30	5	On	On	Off	34	36	27	58	43	0
21 (8-9pm)	30	20	0	50	30	5	On	On	Off	33	29	21	54	43	0
22 (9-10pm)	0	10	0	20	10	5	Off	On	Off	23	22	16	0	8	0
23 (10-11pm)	0	0	0	5	5	5	Off	Off	Off	13	16	10	0	0	0
24 (11-12am)	0	0	0	5	5	5	Off	Off	Off	8	13	6	0	0	0
Total/Day	750	750	280	1060/1115	940/ 985	500/ 525	1500	1600	900	662	690	459	844	761	288
Total/Week		46.30	hours		67.40/ 70.85	hours		100	hours		44.59	hours		52.69	hours
Total/Year		2414	hours		3505/ 3694	hours		5214	hours		2325	hours		2747	hours

^aSchedules for occupancy, lighting, receptacle, HVAC system and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**^bLighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

NEW SECTION

WAC 51-11C-71039 Table B103(9)--School and warehouse occupancies.

Table B103(9) School Occupancy

Hour	of Day (time)			y	Schedule for Lighting ^b /Receptacle Percent of Maximum Load Wk Sat Sun			Schedule for HVAC System Wk Sot Sup			Maximum Load			Schedu 1	Schedule for Elevator Percent of Maximum Load		
		Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	
1	(12-1am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0	
2	(1-2am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0	
3	(2-3am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0	
4	(3-4am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0	
5	(4-5am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0	
6	(5-6am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0	
7	(6-7am)	0	0	0	5	5	5	Off	Off	Off	5	3	3	0	0	0	
8	(7-8am)	5	0	0	30	5	5	On	Off	Off	10	3	3	0	0	0	

Houi	of Day (time)	Schedule for Occupancy Percent of Maximum Load		Schedule for Lighting ^b /Receptacle <i>Percent of</i> Maximum Load			Schedule for HVAC System Wk Sat Sun			Maximum Load n Wk Sat Sun			Schedule for Elevator Percent of Maximum Load			
	-	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
9	(8-9am)	75	10	0	60/85	15	5	On	On	Off	34	3	5	30	0	0
10	(9-10am)	90	10	0	65/95	15	5	On	On	Off	60	5	5	30	0	0
11	(10-11am)	90	10	0	65/95	15	5	On	On	Off	63	5	5	30	0	0
12	(11-12pm)	80	10	0	65/95	15	5	On	On	Off	72	5	5	30	0	0
13	(12-1pm)	80	10	0	55/80	15	5	On	On	Off	79	5	5	30	0	0
14	(1-2pm)	80	0	0	55/80	5	5	On	Off	Off	83	3	5	30	0	0
15	(2-3pm)	80	0	0	55/80	5	5	On	Off	Off	61	3	3	30	0	0
16	(3-4pm)	45	0	0	50/70	5	5	On	Off	Off	65	3	3	15	0	0
17	(4-5pm)	15	0	0	35/50	5	5	On	Off	Off	10	3	3	0	0	0
18	(5-6pm)	5	0	0	35/50	5	5	On	Off	Off	10	3	3	0	0	0
19	(6-7pm)	15	0	0	35	5	5	On	Off	Off	19	3	3	0	0	0
20	(7-8pm)	20	0	0	35	5	5	On	Off	Off	25	3	3	0	0	0
21	(8-9pm)	20	0	0	35	5	5	On	Off	Off	22	3	3	0	0	0
22	(9-10pm)	10	0	0	30	5	5	On	Off	Off	22	3	3	0	0	0
23	(10-11pm)	0	0	0	5	5	5	Off	Off	Off	12	3	3	0	0	0
24	(11-12am)	0	0	0	5	5	5	Off	Off	Off	9	3	3	0	0	0
Total	'Day	710	50	0	750/990	170	120	1500	500	0	691	80	84	285	0	0
	Week		36.00	hours		40.40/	hours		80.00	hours		36.19	hours		14.25	hours
Total	Year (1877	hours		52.40 2101/ 2732	hours		4171	hours		1887	hours		743	hours

^aSchedules for occupancy, lighting, receptacle, HVAC system and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**^bLighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

Table B103(10) Warehouse Occupancy

		G 1	116		G 1 1 1	е т.	1 4 h/				Sched		Service			
			edule f		Schedule							Hot		C - L - J	e	Elevator
			cupanc	•		eceptacle		6.11	1. 6 1		١,	Water				
**	(CD) ((1))		ercent o			rcent of			ule for l			Percent			Percent	- 3
Hour	of Day (time)		mum L			mum Le			System			<u>kimum</u>			ximum	
- 1	(12.1)	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1	(12-1am)	0	0	0	5	5	5	Off Off	Off	Off Off	2	2	2	0	0	0
2	(1-2am)	0	0	0	5 5	5 5	5 5	Off	Off Off	Off	2 2	2	2	0	0	0
3	(2-3am)	-	0	-	-	-		-			2	2	2	Ŭ	0	
4	(3-4am)	0	0	0	5	5 5	5	Off	Off	Off	5	2 2	2	0	0	0
5	(4-5am)	0	0	0	5	-	5	Off	Off	Off	3 7		2	0	0	0
6	(5-6am)	0	0	0	5	5 5	5	Off	Off	Off	7	2	2	0	0	0
/	(6-7am)	0	0	0	5	-	5	Off	Off	Off	· '	2	2	0	0	0
8	(7-8am)	15	0	0	25/40	5	5	On	Off	Off	10	2	2	0	0	0
9	(8-9am)	70	20	0	45/70	8	5	On	On	Off	30	6	2	0	0	0
10	(9-10am)	90	20	0	55/90	24	5	On	On	Off	36	12	2	0	0	0
11	(10-11am)	90	20	0	55/90	24	5	On	On	Off	36	12	2	30	0	0
12	(11-12pm)	90	20	0	55/90	24	5	On	On	Off	46	17	2	0	0	0
13	(12-1pm)	50	10	0	50/80	5	5	On	On	Off	57	4	4	0	0	0
14	(1-2pm)	85	10	0	55/90	5	5	On	On	Off	43	4	4	0	0	0
15	(2-3pm)	85	10	0	55/90	5	5	On	On	Off	38	2	2	0	0	0
16	(3-4pm)	85	10	0	55/90	5	5	On	On	Off	40	2	2	40	0	0
17	(4-5pm)	20	0	0	55/90	5	5	On	Off	Off	30	2	2	0	0	0
18	(5-6pm)	0	0	0	30	5	5	Off	Off	Off	18	2	2	0	0	0
19	(6-7pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
20	(7-8pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
21	(8-9pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
22	(9-10pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
23	(10-11pm)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0
24	(11-12am)	0	0	0	5	5	5	Off	Off	Off	3	2	2	0	0	0

Hour of Day (time)	O P	nedule fo ccupanc ercent of imum L	y f	Pe	for Lig ceptacle rcent of mum Lo	:		ule for l		i	lule for S Hot Water Percent o ximum 1	of	Sched	ule for l Percent ximum	
• ` ′	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
Total/Day Total/Week	680	120 35.20			180 33.00/ 48.75	120 hours	1000	800 58.00	0 hours	429	91 22.88	52 hours	70	0 3.50	0 hours
Total/Year		1835	hours		1716/ 2542	hours		3024	hours		1193	hours		182	hours

^aSchedules for occupancy, lighting, receptacle, HVAC system and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5 percent emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0 percent when occupancy is 0 percent. **These values may be used only if actual schedules are not known.**

^bLighting profiles are modified to reflect the requirement for occupancy sensors in Section C405.2.

NEW SECTION

WAC 51-11C-80000 Appendix C--Exterior design conditions. As required by Sections C302.2 and R302.2, the heating or cooling outdoor design temperatures shall be selected from Table C-1.

NEW SECTION

WAC 51-11C-80100 Table C-1--Outdoor design temperatures for Washington.

Table C-1
Outdoor Design Temperatures

Location	Outdoor Design Temp. Heating (°F)	Outdoor Design Temp. Cooling (°F)
Aberdeen 20 NNE	25	83
Anacortes	24	72
Anatone	-4	89
Auburn	25	84
Battleground	19	91
Bellevue	24	83
Bellingham 2 N	19	78
Blaine	17	73
Bremerton	29	83

	Outdoor Design Temp. Heating	Outdoor Design Temp. Cooling
Location	(°F)	(°F)
Burlington	19	77
Chehalis	21	87
Chelan	10	89
Cheney	4	94
Chesaw	-11	81
Clarkston	10	94
Cle Elum	1	91
Colfax 1 NW	2	94
Colville AP	-2	92
Concrete	19	83
Connell 4 NNW	6	100
Cougar 5 E	25	93
Dallesport AP	14	99
Darrington RS	13	85
Davenport	5	92
Edmonds	24	82
Ellensburg AP	2	90
Elma	24	88
Ephrata AP	7	97
Everett Paine AFB	21	79
Forks 1 E	23	81
Glacier RS	13	82
Glenoma (Kosmos)	18	89
Goldendale	7	94
Grays River Hatchery	24	86
Greenwater	1.4	84
Grotto	21	84
Hoquiam AP	26	79
Inchelium 2 NW	0	92
John Day Dam	19	100
Kent	21	85
Kirkland	17	83
La Grande	23	88
Leavenworth	-3	93
Little Goose Dam	22	101
Long Beach 3 NNE	25	77
Longview	24	87
Lower Granite Dam	14	98
Lower Monument Dam	18	103
Marysville	23	79

	Outdoor Design Temp. Heating	Outdoor Design Temp. Cooling
Location	(°F)	(°F)
Metaline Falls	-1	89
Methow 2 W	1	89
Nespelem 2 S	-4	93
Newhalem	19	89
Newport	-5	92
Northport	2	92
Oak Harbor	16	74
Odessa	7	100
Olga 2 SE	24	71
Olympia, AP	17	85
Omak 2 NW	3	90
Oroville	5	93
Othello	9	98
Packwood	16	90
Plain	-3	89
Pleasant View	16	98
Pomeroy	3	95
Port Angeles	28	75
Port Townsend	25	76
Prosser	12	97
Puyallup	19	86
Quilcene 2 SW	23	83
Quinault RS	25	84
Rainier, Longmire	15	85
Paradise RS	8	71
Raymond	28	81
Redmond	17	83
Republic	-9	87
Richland	11	101
Ritzville	6	99
Satus Pass	10	90
Seattle: Sea-Tac AP	24	83
Sedro Woolley 1 E	19	78
Sequim	23	78
Shelton	23	85
Smyrna	8	102
Snohomish	21	81
Snoqualmie Pass	6	80
Spokane AP	4	92
Spokane CO	10	96
Stampede Pass	7	76

	Outdoor Design Temp. Heating	Outdoor Design Temp. Cooling
Location	(°F)	(°F)
Stehekin 3 NW	12	85
Stevens Pass	6	77
Tacoma CO	29	82
Tatoosh Island	31	63
Toledo AP	17	84
Vancouver	22	88
Vashon Island	28	78
Walla Walla AP	6	96
Waterville	1	88
Wellpinit	1	93
Wenatchee CO	10	92
Whidbey Island	11	71
Willapa Harbor	26	81
Wilson Creek	3	96
Winthrop 1 WSW	-12	91
Yakima AP	11	94

ABBREVIATIONS:

AFB Air Force Base AP Airport CO City Office RS Ranger Station

Typical: "4(miles)NE"